THE CHEMICAL ATLAS.

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James. G. Wood

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James E. Wood 61667

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THE

CHEMICAL ATLAS,

OR

TABLES:

SHOWING AT A GLANCE

THE OPERATIONS OF QUALITATIVE ANALYSIS,

WITH

Practical Observations,

AND

COPIOUS INDICES OF TESTS AND RE-ACTIONS;

ACCOMPANIED BY

A DICTIONARY OF SIMPLE AND OF COMPOUND SUBSTANCES,

INDICATING THE TESTS BY WHICH THEY MAY BE IDENTIFIED.

AND

A DICTIONARY OF RE-AGENTS,

INDICATING THEIR PREPARATION FOR THE LABORATORY, THE MEANS OF TESTING THEIR PURITY, AND THEIR BEHAVIOUR WITH SUBSTANCES.

BY

A. NORMANDY,

AUTHOR OF "THE COMMERCIAL HAND-BOOK OF CHEMICAL ANALYSIS," &c., &c., AND EDITOR OF "H. ROSE'S TREATISE OF CHEMICAL ANALYSIS."

"GLOMERE LINI EXITUM INVENIES."—*Plin.*

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MANUFACTURERS OF CHEMICAL APPARATUS AND PHILOSOPHICAL INSTRUMENTS.

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PREFACE.

The public being already in possession of H. Rose's "Practical Treatise of Chemical Analysis," which I edited in a complete form about eight years ago; of R. Fresenius's "Instructions on Chemical Analysis," most ably translated by Mr. Bullock; of Mr. Parnell's "Elements of Chemical Analysis," of Dr. Noad's short but excellent book on "Chemical Manipulation;" and of several other compositions of a less elaborate and precise nature on the same subject, I may be permitted, perhaps, to say a few words to explain in what respect the present work differs from its predecessors, and to endeavour to show that, though it cannot in the slightest degree bear comparison with, or supersede the masterly treatises of H. Rose, or of R. Fresenius, yet it may supply what I will venture to assert is a great desideratum: I mean a simple and methodical arrangement, presenting at a glance all the operations of a systematic chemical analysis, and affording the means of an easy and immediate reference.

The present work was first began without any view to subsequent publication, but simply as a guide for the use of my son, and of a few pupils, but gradually as they advanced in their studies, it became necessary for me to enlarge their means of research; and so from their daily work, and from noting down at the time as they occurred, the difficulties, or the unusual, or misapprehended, or misobserved, or mistaken, or misconstrued phenomena, which are sure to present themselves to the beginner (and occasionally indeed to the proficient also), and which I had to explain, to rectify, or to correct,—the present Atlas of Chemical Tables, and the Observations which accompany them, have increased to their present number.

The work being in reality the result of an almost daily practice in the laboratory for the last four years, I hope I may be permitted to say, without violating a becoming reserve, that experience in this respect enables me to affirm that, in spite of the defects which doubtless may be discovered in it, any intelligent person, provided he have some knowledge of chemical manipulation, will be able, almost invariably, to carry on the qualitative analysis of most compounds to a successful issue.

What I now offer, therefore, to the public, and more particularly to the chemical student, and to the manufacturer, miner, and assayer, is a practical guide to chemical qualitative analysis,—an Atlas in which the operations of that branch of chemical research are mapped out, as it were, so as to show, I believe, clearly, and at a glance, not only the various steps of the analysis, but those which lead in the most direct and safe manner to the contemplated end. The ways there pointed out are not all right royal roads, for in the course, so to speak, of a complicated voyage of discovery, there are evidently many shoals to wade through, pitfalls to avoid, and occasionally some danger of collision, but all these will, I trust, be found correctly indicated, or signalized; and I have no doubt but that, if proper attention be paid to the directions given, and to the observations which accompany them, the traveller, if I may be allowed to continue the simile, will find himself safely landed to the desired termination of his journey.

In the Tables, the names of the substances found, or sought for, and those of the reagents used, both for the sake of brevity and of accuracy, are represented by their symbols, and even in the non-tabulated part of the work where the necessity for condensing words into the smallest possible space is less absolute, the symbols are generally retained, but I have given (page 2) a list of all the symbols used in the work, arranged in alphabetical order, so that the reader may, by referring to it, obtain at once the necessary interpretation without loss of time.

The Atlas is accompanied by two concise Dictionaries, one of which is, a list of the simple substances and of their simple combinations, indicating their behaviour with the tests which yield characteristic reactions, and by means of which they may accordingly be identified. Such a Dictionary, in my judgment, was absolutely required; for it is there only that the operator will find all the confirmatory tests to which he is referred in the Tables, and to which it is necessary that the substances found by him should respond before he can confidently trust his analysis; for it is only when a substance exhibits all the phenomena peculiar to it, under the influence of its appropriate tests, that the proof of its identity becomes irresistible.

In the other Dictionary will be found the names of the reagents used in chemical analysis, the manner of preparing them for the laboratory, of ascertaining their purity, and their action on the simple bodies, and on their simple combinations. The object of such a book need scarcely be dwelt upon; there is, however, one of its uses which, though less immediately obvious, will often be found, I trust, a very great help to the chemical student or analyst, I allude to the enumeration of the various precipitates produced by reagents upon compounds, and by means of which the operator, from the observation of one of the reactions produced during the analytical process, may either obtain a clue to the nature of the substances which he will probably have to deal with, or rectify, or abandon surmises which he would thus find at variance, or incompatible with the phenomena observed.

In conclusion, it is scarcely necessary to say that the substance of the present Tables is obviously to be found more or less disseminated in all books on chemical analysis; yet there are two works which have been more especially consulted, namely, and of course, H. Rose's Treatise, and R. Fresenius's Instructions, because the plan described by these eminent men is, in my opinion, the best, and is that which is followed by almost every chemist; not but that the grouping of substances according to the action of certain reagents had been done long before them, for this is, in fact, the very groundwork of qualitative analysis, and originality in this respect is therefore quite out of the question; but to them is due the great merit of having arranged the details of this grouping into more minute and elaborate order, and of having collected and systematically arranged the reactions and tests by means of which chemists identify the various substances which may be the object of analytical research; and I claim nothing more than having attempted to arrange in a tabular, comprehensive, and clear form, the operations thus known to, and followed by, chemists in the qualitative analysis of compounds, so as to keep every step of the process constantly before the eyes of the operator whilst he progresses with his investigation, thus obviating the troublesome skipping and dodging from this to that page, and thence back again, with sundry sidlings, and through all the perplexities of numbers both Roman and Arabic, intermingled with several alphabets, from large Roman capital A to small italic *z*, and from alpha to omega, a system of reference perfectly bewildering, especially to the neophyte, and to which authors have inevitably been constrained to resort in other arrangements. I have likewise added to the Tables the observations which the actual practice of the students pointed out as necessary to the complete and thorough apprehension of the operations alluded to in the Tables; and how far I have been successful in thus clearing up the doubts which might arise in the prosecution of the analysis, it is now for the candid reader to decide.

Since the work has been printed I have detected a certain number of errors which had escaped me, some in the construction of the Tables, others in the correction of the proofs; for all those which I have thus discovered I beg to refer the reader to the page of Errata at the end, and if he will kindly make the necessary corrections no other disadvantage will accrue than the trouble which I am thus obliged to ask him to take; but for such errors as may have escaped me altogether, I must entirely depend on his indulgence, trusting that he will not find too frequent an opportunity of, or any really strong cause for, exercising it, and that, notwithstanding such drawbacks, he may still be able to concede, after having once plunged into the intricacies of an analytical examination, that, after all, he has been guided well enough to enable him to make a successful exit from the labyrinth.

A. NORMANDY.

67, Judd Street, Brunswick Square,
16*th June*, 1856.

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PRELIMINARY OBSERVATIONS

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PROCESSES EMPLOYED, AND GENERAL RULES TO BE FOLLOWED, IN PERFORMING CHEMICAL ANALYSIS.

All substances which may be met with in nature are, of course, either simple substances, or compound substances.

Any process or series of processes through, or by means of which, the constituent parts of compounds can be isolated or separated, their nature or properties recognized, and their proportions determined, or by which the substance itself, if it be a simple body, can be identified, is called chemical analysis.

Chemical analysis is, accordingly, divided into two branches, namely :—

Qualitative Analysis, which contemplates the detection of the presence of the constituents of the compound by submitting it to the action of certain tests or reagents, by means of which the *quality* of the constituent parts may be determined, and their identity verified and proved.

Quantitative Analysis, which has in view the determination of the *quantity* or amount, in either weight or bulk, of the component parts just alluded to.

Qualitative analysis must, therefore, be the first step in all analytical investigations, for it is clear that we must know what the constituents of a compound are before we can determine their amount or quantity; and although in some few rare instances quantitative analysis may be at once proceeded with, yet it is better, generally quicker, and I may say it is certainly safer, not to omit the qualitative examination, for I know of numberless and egregious mistakes referable to that omission.

The substance to be qualitatively examined may be—

A simple substance, that is a metalloïd, or a metal—an alloy—an oxyde—a base—an acid—a salt—a binary compound resulting from the combination of metalloïds with metals, or of different metalloïds together—or lastly, it may be a mixed compound containing all the above substances, and it may be in a solid or in a liquid state.

If in the solid state, after submitting it to several preliminary tests described in the Tables, the operator will have to examine how it can be dissolved in order to examine its solution by the appropriate reagents.

Every circumstance of form, of colour, of odour, of taste is a useful indication, and should be carefully noted by the analyst; thus, for example, the long prismatic needles of *crystallized chloride of strontium* may afford a means of distinguishing it from *crytallized chloride of barium*, which is always in flat four-sided tables.

Again, not only have salts, generally, a crystallized form, or may, by proper treatment, be made to assume one, but whilst most of them are colourless, or white, several have a well defined, and perfectly characteristic colour, the colour depending in general on the base which they contain; the alkalies, the earths, and some metallic oxydes form colourless salts when the acids with which they are combined are colourless; all the chromates are yellow, or orange-red, or bright-red; those of cobalt are deep pink or rose-red (see the list of salts in reference to their colour).

Again, the salts of the same base have always, or almost always the same taste *when they are soluble*, for those which are insoluble are of course, insipid, the sensation of taste depending upon a portion of their mass being dissolved by the saliva; thus, all the salts of magnesia are bitter, those of lead, and of alumina have a sweet and then an acid, or styptic, or astringent taste (see the list of salts in reference to their taste). The operator, however, will recollect that MANY SALTS ARE HIGHLY POISONOUS, *wherefore some caution must be exercised in tasting them.*

In the same way an effervescence without odour indicates the presence of carbonates; an odour of sulphuretted hydrogen, that of sulphurets; of cyanogen, that of cyanides; an odour of chlorine, that of certain peroxydes, or other salts mentioned in col. 6, Table I.—E; an odour of sulphurous acid, that of sulphites, and hyposulphites; and all these odours being quite peculiar, are therefore characteristic.

If the compound be in the liquid state, then the liquid must of course have either a neutral, an acid, or an alkaline reaction. An acid reaction indicates either the presence of a free acid, or of an acid salt, or of a neutral salt of the heavy metallic oxydes; an alkaline reaction the presence of a free alkali, or of a basic, or neutral alkaline carbonate, or of a free alkaline earth, or of a compound soluble in an alkaline liquid as will be more particularly shown in Table VII. It will also be necessary to ascertain whether it is sufficiently concentrated to be submitted to analysis, whether it does not contain too large a proportion of free acid, or whether it consists of acids only. The processes for acquiring this preliminary knowledge are given in the observations on the analysis of mixed compounds, Table XIV.

In order to perform an analysis several apparatus are necessary, yet with a few flasks, glasses, tubes, evaporating dishes or porcelain capsules, and a spirit lamp, most analytical operations may be achieved, the success depending much more upon certain precautions in manipulating than in the completeness or expensiveness of the utensils, or of the laboratory. (See the list of the necessary apparatus and reagents.) Supposing, however, that the operator knows how to filter, wash and dry precipitates, &c., blow with the blow-pipe and other little attainments which, if not already possessed, can be acquired in a very short time, we shall only observe :—

That before beginning the regular or systematic analysis of a compound the operator should make it *an invariable rule* to submit it to certain preliminary operations by which not only the probable nature of the compound can be surmised, but by which the substance itself, or some of its constituents can frequently be perfectly identified. These extremely important preliminary operations are fully detailed in the Tables from Table I. to Table III., AND ALL THE OPERATIONS THERE DETAILED SHOULD BE ENTIRELY AND CAREFULLY GONE OVER before attempting the regular and systematic analysis of the substance.

The operator will bear in mind also that the solution of substances is greatly promoted by *pulverization*, the action of solvents upon solids being often and altogether dependent upon their greater or less state of division previous to their being subjected to the action of solvents, and that solution is generally, but not always, accelerated by heat, yet there are a few substances the solution of which is, on the contrary, retarded thereby, such for example, lime, magnesia, sulphate and seleniate of soda.

When the solid to be pulverized is hard and in large masses, the best way is to wrap it up in several folds of thick brown paper, and so crush it therein by the blow of a hammer, or by squeezing it in a strong vice. The smaller particles detached from the mass by either of these means are then more easily reduced to powder in an ordinary mortar, and finally in one of agate; if the substance be very hard it should be pounded into coarse powder by hammering it on an anvil between folds of thick brown paper, and the pulverization is afterwards completed in an agate mortar only, and not in an ordinary mortar.

In order to ascertain whether the solvent employed has dissolved any portion of the mass submitted to its action, as likewise whether a precipitate has been washed long enough, a few drops of the liquid, or of the filtrate, are to be placed upon a strip of platinum foil and evaporated. If these few drops, being in their natural state vapourizable without residue, disappear without leaving anything on the strip of platinum foil, even after making the latter red-hot, then it is a sign that nothing has been dissolved by the menstruum employed, or by the water used for washing the precipitate; in the contrary case, a residue will be left on the foil. It may be sometimes necessary to evaporate a larger quantity than a few drops, in which case the platinum foil is replaced by a small platinum capsule.

From the behaviour of solvents with the substance under examination an insight into its nature, or of the class or group to which it belongs may often be obtained. For example, if the substance be altogether insoluble in water, it cannot be either a chlorate, nor a nitrate, nor a hypophosphite, nor a hyposulphate, since all chlorates, nitrates, hypophosphites, hyposulphates, are soluble in that menstruum; and, on the other hand, if the substance dissolve in water, and is a carbonate, it must be a carbonate of alkali, since all other carbonates are insoluble (see the list of salts which are soluble, or insoluble in water), and in the same way, if, on adding water to a liquid the latter turns milky, a salt of tin, of antimony, of bismuth, &c., is probably present; and, again, the action of hydrochloric, of sulphuric, and of nitric acids, of aquaregia give rise to peculiar phenomena which are often perfectly conclusive, as described in Tables I.—C. and E.

In treating by an acid those substances which have refused to dissolve in water, gases or fumes are frequently evolved with extreme rapidity and violence, even in the cold; and it sometimes happens that the acid poured on the compound appears at first to have no, or scarcely any, effect upon it, when almost all of a sudden, and especially if heat be applied, a most energetic and nearly uncontrollable action sets up, in consequence of which the contents of the vessel overflow, or are squirted out, unless some caution be exercised—wherefore the operator should only pour a small quantity of acid at first, and after a short time, and not before any effervescence which the acid may have at first produced has subsided.

a fresh quantity of acid is again added, and so on by small quantities at a time, heat being applied towards the end, and continued until all that can be dissolved by the acid has been taken up, taking care that the liquid in the flask does not come below the ring of the retort-stand on which it is supported, for in such a case the projected or condensed portions of the liquid coming in contact with the heated glass will almost inevitably cause its fracture. Beakers, or capsules of glass, containing solutions or liquids, are much exposed to be broken by exposure to the direct flame of a lamp, but by placing those vessels upon a piece of wire gauze an accident of that kind seldom happens; the operator will also find it very convenient to replace the glass, or metallic chimneys of lamps, by chimneys made of wire gauze, which present the triple advantage of not being liable to be broken, of allowing the state of the flame to be at all times seen, and of being readily removed, as they always remain cool enough to be comfortably handled.

Even when there is abundance of the substance to be analyzed, it is advisable not to operate upon too large quantities, on account of the difficulty of washing bulky precipitates, and of the size of the funnels and beakers which too large an amount of substance renders necessary. A mass equal to twenty or twenty-five grains will be found in most instances a convenient quantity, or a larger quantity of the substance, 100 grains for example, or even more, may be at once dissolved in about three ounces of water, or of the proper solvent, or diluted subsequently to that extent, and the operator may then divide it into three portions, one of which is devoted to the detection of the bases, the other to that of the acids, and the third to special testing, and as a reserve.

In analytical operations the utmost *order* and *cleanliness* must be scrupulously attended to, and none but reagents in the state of the greatest chemical purity must be employed; *order*, without which great inconvenience, confusion, and mistakes will be sure to happen; *cleanliness*, without which reagents, however pure, will inevitably give incorrect results, and will, just as if the reagent was impure, simulate the presence of substances which may not exist in the compound under examination.

Take care, therefore, that every vessel, beaker, tube, &c., is rinsed with some distilled water before using it, and return the reagents to their respective places on the shelf *immediately* after use, for otherwise the table on which the analytical process is carried on will soon become so crowded with bottles of all manner of sizes and description, that it will be almost impossible to avoid errors, not to speak of the extreme discomfort of such a slovenly practice.

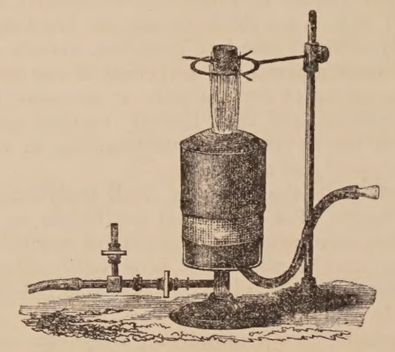
Make it a general rule not to pour a liquid into a filter for the purpose of separating the precipitate which it may contain, without first wetting the filter with distilled water, and allowing it to drain through, since otherwise the pores of the paper, becoming blocked up by the finer particles of the precipitate, would retard or altogether impede the operation. The filter should always be shorter than the funnel which supports it, that is to say, the filter should not project beyond the brim of the funnel, and the vessel put under it for the purpose of collecting the filtrate should always be clean, and of sufficient capacity to contain the whole of the liquid to be filtered, which liquid should never be poured directly from the beaker into the filter, but always along a moistened glass rod, and not in the middle of the filter, but on the sides thereof, in order to avoid as much as possible the chance of its bursting.

For the purpose of filtering rapidly, my platinum-wire filter-support will, I think, be found very convenient. The filter of paper is placed into the platinum-wire support, which is itself placed in a glass funnel, the paper being thus prevented from coming in contact with the glass of the funnel, the filtering proceeds with great rapidity.

When the precipitate produced by a reagent is bulky and light, it is advisable to shake it vigorously in the vessel which contains it, or in cases where there is no danger of loss by spirting, or priming, or by the volatilization of an essential constituent it agglomerated by boiling, and then the whole is left to stand for some time, so that the precipitate may settle well, for otherwise it will be liable to pass through the filter, and the filtrate, instead of being clear, will be turbid or milky. It is true that by putting the turbid filtrate back again into the filter once, or a greater number of times, the liquid will eventually pass clear, but besides the annoyance of having thus to refilter the liquid, it generally happens that when it at last passes in a clear state, the filtration proceeds then very slowly, because the pores of the filter are blocked up by the fine particles which were held in suspension before. The precipitate should, therefore, be allowed to settle well before filtering, since, the superincumbent liquor, being clear, will, on being decanted into the filter, pass through it much more rapidly than it otherwise would, and thus much tedium will be spared. In fact, when practicable, it is always better, and it eventually saves time, to effect the separation of precipitates by decantation than by filtering. The washing of precipitates may be performed by pouring a pretty large quantity of water over the precipitate, stirring or shaking the whole well, allowing to subside, and pouring off the clear superincumbent water into the filter; a fresh quantity of water is added with which the precipitate is again well stirred, allowed to subside, the superincumbent water is again poured off, and finally the precipitate, or residue itself, is thrown upon the filter. It often happens, however, that the precipitate is so light that decantation becomes impracticable, or tedious unless heat is applied; in such cases, the liquid containing the precipitate had better be transferred to a beaker, and a gentle heat being applied, will generally hasten the settling of the precipitate, so that the superincumbent liquid may, without difficulty or great loss of time, be decanted into a filter.

When a precipitate is formed in a coloured liquor, it is frequently difficult to ascertain the real colour of the precipitate; thus, for example, a white precipitate in the solution of a chromate will appear yellow, or green, according to the hue of the liquor. By standing, however, the precipitate will settle at the bottom of the vessel, and its colour may then be correctly appreciated; but if there be the slightest doubt on the subject, filtering should be resorted to.

When a precipitate is to be ignited, a small porcelain or platinum crucible, as the case may be, is ordinarily employed, the bulk of the precipitate being generally small in quantitative, and may always be rendered so in qualitative analysis. When the laboratory furnace is alight, this can of course be at once done; but it frequently happens that the furnace not being in use, it becomes necessary, or at any rate it is more convenient, to employ another source of heat. Where coal gas is used as a source of heat, my improved gas blow-pipe furnace will, I think, be found to possess advantages which cannot be realized by any other means. It will be found very convenient for analysis, for fusing and igniting substances, and indeed for all purposes for which either a moderate, or the most intense heat is required.



The apparatus, as shown in the above Figures, one-sixth of the real size, consists of a wire-gauze cylinder partly cased in sheet iron in communication at the lower part with the atmospheric air, and closed at the upper part by a diaphragm of wire gauze of about 700 openings to the square inch, and provided with a short, slightly conical cover perforated in the centre. A blow-pipe jet placed outside the cylinder traverses the diaphragm, and opens on a level with the aperture of the cover. The construction of this furnace is very similar to my first contrivance, published seven years ago. It differs from it in this, namely:—

The mixture of air and of gas is more intimate, and the heat produced is accordingly more intense.

The stream of cold air which is constantly rushing through the meshes of the wire gauze always keeps the body of the furnace in a cool state, so that it can at any moment be handled as if it were not lighted.

It has no chimney, and therefore allows the fusion of substances and other operations to be more easily watched and adjusted, and to be carried on the laboratory or working table as if an ordinary gas-burner only were employed.

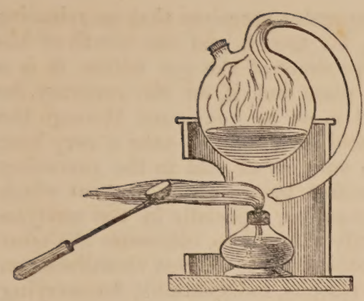
When in use, it is only necessary to place the furnace over the cross bars screwed on to the top of an ordinary burner; and on opening the stop cock, a mixture of air and gas is immediately obtained, which, being inflamed at the top, burns with a clear, blue, smokeless, and exceedingly hot flame, by means of which a gallon of water can be brought to the boiling point in about twenty minutes.

If a greater degree of heat is required, a blast of air is sent into the centre of the flame by means of a flexible tube of vulcanized caoutchouc, either from the mouth, a pair of bellows, or any other contrivance, a blow-pipe flame being thus produced of the greatest intensity, by means of which 100 grains of silica mixed with 400 grains of carbonate of soda, can be brought to and kept in a state of perfect fusion for any length of time, such a degree of heat being well adapted to the various requirements of the laboratory. Fig. 1, represents that apparatus. A greater heat may still be secured by coiling the blow-pipe into the flame at the top, so as to blow hot air.

If only a moderate or simmering heat is wanted to play under a large surface—for the purpose, for example, of evaporating solutions or liquids—the cap or cover may be removed, and the operator, by means of the stop-cock, can then regulate, on the surface of the diaphragm of wire gauze, the amount of heat which may be suited to his work or experiment. See Fig. 2.

To render the instrument complete, it is furnished with a stop-cock at one side, and provided with a jet, adapted for using an ordinary mouth blow-pipe.

But when coal gas is not comeatable, the well known eolypile may be resorted to, in which case the crucible is supported upon a ring of iron-wire fixed to a wooden handle, and held before the jet of flame, as here represented:—



Ignition may of course be performed also by means of an Argand spirit lamp.

With respect to the use of platinum crucibles and capsules, as they are liable to be injured by various substances, attention must be paid to the following directions :—

Never melt in a platinum crucible.

1° Caustic alkalies, or alkaline nitrates; consequently no saltpetre, caustic potash, or caustic soda.

Because in such a case protoxyde of platinum will be formed at the expense of the crucible; the protoxyde of platinum thus formed dissolves in the alkali, and gives it a green colour.

Yet caustic alkalies may be fused, in conjunction with alkaline carbonates, in platinum utensils, by first putting therein the pulverized carbonate, making a slight cavity in the middle by pressing it with the tip of the finger, and then placing the fragment of caustic potash, or soda, in that cavity; after which, the whole may be fused without danger to the crucible.

A mixture of nitrate, and of carbonate of alkali, attacks platinum very rapidly.

2° No alkaline or arsenical sulphurets, nor sulphates mixed with charcoal powder.

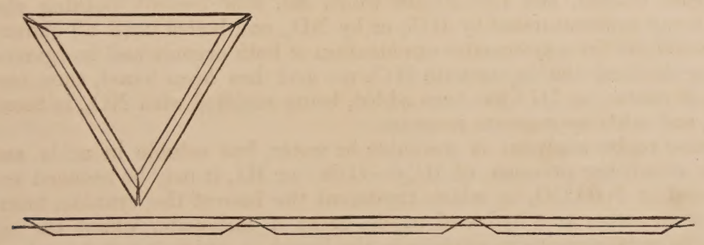
Because alkaline sulphurets act upon platinum with still greater energy than caustic alkalies.

Bisulphate of potash, fused in platinum, attacks the metal.

3° No metallic substances, nor any mixture which may yield a metallic residue—such as, for example, metallic salts containing an organic acid, or metallic oxydes with charcoal, whereby the metal would be reduced.

Any pulverized compound, which turns black on being drenched with NH_4S, should not be heated in a platinum crucible, as this is a sign that some metal is present which might become reduced.

Platinum crucibles should not even be heated upon iron-wire triangles, for they become eventually damaged at the point of contact with the iron. This may, however, be guarded against by wrapping up the iron wire with a little platinum foil at those parts on which the crucible rests, or, better still, by uniting three pieces of tobacco pipe with an iron wire passed through the hole of the stem of the pipe, so as to form a triangle. This little arrangement, contrived by Mr. Thomas Taylor, answers the purpose admirably, and it is represented in the following figure :—



Gold, *silver*, and *copper* may, however, be heated to redness in platinum crucibles, but the heat must not be carried up too near the point at which these metals fuse. *Melted lead* cannot be poured even into a cold platinum crucible without spoiling it.

A drop of *lead*, of *tin*, or of *bismuth*, falling upon a red-hot platinum vessel, invariably makes a hole in it.

4° No phosphorus, or phosphoric acid, or phosphates mixed with combustible substances, nor any mixtures which can yield phosphorus.

Because they would form phosphuret of platinum, in consequence of which the crucible would be melted at that point, or would become shrivelled up.

5° Nor any mixture of sulphuric and boracic acid, for although neither of these acids have separately any action upon platinum, they have jointly a powerful action upon it.

6° Metallic oxydes, even *per se*, should not be exposed to a white heat in platinum utensils, because it often happens that at such a temperature they part with their oxygen, in consequence of which, their metal being revived, forms an alloy with the platinum, which is thus irretrievably damaged. The metallic oxydes which have the most tendency to become thus reduced are those of *lead*, of *tin*, of *antimony*, of *bismuth*, of *copper*, of *nickel*, and of *cobalt*.

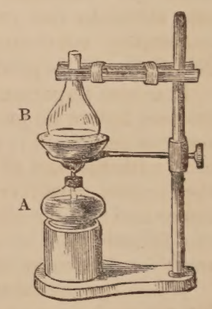
If, however, the heat is moderate, they undergo no change; but if there is the smallest particle of organic matter, a fragment of filtering paper, for example, with *oxyde of lead*, the metal will be reduced at a red heat, and a hole will be made in the crucible.

7° Platinum combines easily with silicium, and with carbon at a high temperature, wherefore the contact of platinum crucibles with coke or with charcoal in the furnace must be avoided by inclosing the platinum vessel in a Hessian crucible.

8° Platinum must never be used with any substance capable of evolving *chlorine*, wherefore *aqua regia*, even very dilute, or mixtures of chlorides and saltpetre or other nitrates, must not be put into platinum utensils, nor must substances containing manganese be treated in platinum capsules with muriatic acid, because chlorine, being disengaged, would attack the platinum. When a mineral substance to be analyzed, and having been fused in a platinum crucible with an alkaline carbonate, yields a fused mass of a green, or of a black colour, it should be detached from the crucible by gently bending the latter between the fingers; the detached mass should then be treated with HCl, in a vessel of glass or porcelain, and evaporated therein until all odour of chlorine has disappeared.

9° Bromine acts on platinum vessels like chlorine.

In the course of an analysis the operator will occasionally have to evaporate solutions to dryness. If the solution is a dilute one, the evaporation may be begun with an ordinary fire, or by means of a spirit or gas lamp, or sand bath, keeping the liquid on the very verge of boiling, without permitting it actually to boil, for otherwise small particles will be sure to be projected all round the capsule upon the table; it is only when the liquor has become concentrated that the evaporation should be carried to dryness, by means of the water bath, in order to prevent loss by spirting, or the volatilization of certain substances. If, however, the operator have reason to know that the solution contains no substances capable of being dissipated by heat, he may use a stronger heat than that of the steam bath, taking care to reduce the heat towards the end, and to stir the mass without interruption with a glass-rod, otherwise projections will be sure to take place; or he may cover the capsule, into which the evaporation is effected, with a funnel somewhat smaller than the capsule, and provided with a large neck. A funnel, the spout of which has been cut off at a suitable distance, or a Florence flask, properly cut, answers the purpose exceedingly well. The arrangement is represented in the adjoining Figure, in which A is the capsule, and B an inverted Florence flask, the bottom of which has been removed, and which is held over the capsule by a clip made of two strips of wood, bound by a ring of vulcanized india rubber; or else the liquor may be transferred to a Florence flask, and the latter being placed on a retort ring at an angle of about 45°, the evaporation may be pretty rapidly carried on without fear of projections, except when a sediment is forming at the bottom of the flask which thus becoming unduly heated produces, from time to time, an ebullition in somewhat explosive bumps which may forcibly eject part of the contents of the flask.



By referring to the classification of bases and of acids, and to the Tables, the student will perceive that only a few general reagents are employed for the purpose of separating them into divisions or groups, which are gradually subdivided again and again by other reagents, which, having a special mode of action, serve ultimately to isolate and identify the compound, and which are for this reason called *special reagents*, in contradistinction to the others, which are called *general reagents*.

The general reagents for the detection of bases and metallic acids are only three in number; they are—

Hydrosulphuric acid (sulphuretted hydrogen), HS.
Hydrosulphuret of ammonia, NH_4S.
Carbonate of ammonia, of soda, or of potash, NH_4O,CO_2 (or NaO,CO_2, or KO,CO_2).

The operator should also recollect that no substance can be clearly identified by one test alone, and that it is only when the substance found by analysis complies with, or answers to the *ensemble* of the reactions peculiar to that substance that the conviction of its identity becomes irresistible; wherefore he should never omit to submit it to the confirmatory tests mentioned in the Dictionary of the behaviour of simple substances, and of their compounds with reagents, which confirmatory tests could but seldom be indicated, for want of room, in the Tables.

But whether the reagents employed are general or special, the operator must take care that he uses a sufficient but not an extravagantly large quantity of them. Thus, for example, if he be directed to acidify a solution, a few drops of acid—that is, a few drops above what is necessary to neutralize the liquid, or to impart a distinctly acid reaction to it—is all that is required; and, in the same manner, when he is directed to dissolve the substance in a given acid, he should not use much more of that acid than is adequate to effect the solution, since the presence of a large excess of acid interferes with the action of many reagents; for example, lead, which is so readily precipitated from an *acidified* liquor by HS, is precipitated but very imperfectly, or perhaps not at all, by that reagent in a strongly acid solution. The liquid to be treated by HS should also be sufficiently diluted with water, because in many cases no

precipitate is produced by that reagent until this has been done; neither should he be in a hurry to conclude that because a certain reagent does not produce at once a precipitate, the substance sought for is absent, since in many cases some length of time, and occasionally a considerable time, must elapse before the reaction becomes manifest. The solutions which are thus difficult to precipitate by HS are those of SnO_2 and AsO_5, and even AsO_3, and heat must be applied so that the liquor may be warm. Remember also that stirring and shaking have always a very great influence on chemical affinities, so much so that many tests altogether fail in producing any reaction when the mass to which they are added is left undisturbed, whereas, on the contrary, by briskly shaking it, the characteristic effect is produced; for example, a solution of potash is scarcely affected by merely pouring one of Tartaric acid into it, but if the mass be vigorously shaken, a white granular precipitate immediately makes its appearance. As a rule, therefore, the liquor should always be strongly shaken after the addition of a reagent.

Whether a substance is soluble in water or not, is known by treating a portion of it previously well pulverized with pure distilled water, boiling, filtering, and evaporating a few drops of the filtrate upon a strip of platinum foil. If a residue is left thereon, it is a proof that it is at least partially soluble in that menstruum, and this is also the method resorted to for ascertaining the solubility of the substance in acids. It is necessary, as we already said, to reduce the compound into fine powder previous to submitting it to the action of the solvent, since the complete, or partial solution of the mass often depends upon this operation. When, however, the compound is readily soluble in water, or in acids, this precaution may be omitted.

Before concluding to the insolubility of the compound in acids, take care to dilute the acid employed (unless otherwise directed) with a sufficient quantity of water, and to shake or stir the whole well, for some substances which are only sparingly soluble, or altogether insoluble in the concentrated acid, dissolve immediately upon addition of water; such is the case with carbonate of Barytes for example, if concentrated HCl be poured upon that compound, no action whatever will be perceived, or if one is observed it will soon stop, but on diluting with water, a violent effervescence takes place, and a solution of chloride of barium is readily obtained.

And for an analogous reason (except in certain cases where concentrated solutions must absolutely be used in order to be affected by the reagents employed) the operator should always dilute with a sufficient quantity of water the liquor to be tested, since if this be not done, liquids which contain no base whatever may simulate the presence of one. For example, suppose the liquid under examination to be simply a moderately concentrated solution of oxalic acid, on adding NH_3 or NH_4Cl to it, a precipitate of $NH_4O,\overline{O}$ will be produced.

It is also important that the operator should use only a small portion of the solution with each general reagent before he proceeds to treating the whole liquor with it; if the action due to the presence of the reagent employed is produced with the small portion of liquor submitted to its action, then he may proceed with the rest of the solution as with the sample first tested, submitting the whole to the action of the reagent whatever it be, as long as it is affected by it, which is known by filtering a portion of the liquor and testing the filtrate. If the reagent employed produces still a precipitate, or turbidness in the filtrate, then it is a proof that all that which the reagent can eliminate is not yet separated, and therefore more of it must be added.

When the operator is directed to use a reagent to supersaturation, for example, to pass a stream of HS through an acid liquor to supersaturation; he must guard against deceitful appearances. Thus, it will not be sufficient for him merely to smell the liquid, and conclude from a strong odour of HS being perceived, that the liquid is supersaturated with the gas, for the odour might be due simply to the atmosphere of HS which floats over the liquid through which the stream is passed. A liquor is known to be supersaturated with that gas when, after shaking it, or blowing on the surface with a glass tube in order to expel the stratum of HS, a strong odour of the gas is perceived. A long time is often necessary before this takes place. The liquor is known also to be supersaturated with the gas by closing the flask containing it with the thumb, and violently shaking the liquid, if the operator perceives that on releasing the pressure of his thumb, bubbles are forcing their way out between his thumb and the mouth of the flask—if he feels, in fact, that his thumb is gently pushed up by the pressure of the gas within, it is a proof that the saturation is complete; whilst if no such effect take place, but if, on the contrary, he feels that his thumb is, as it were, sucked in, then the current of HS must be continued through the solution. He must also bear in mind that some substances—arsenic acid for example—take a very long time to be completely precipitated by HS; he should therefore make sure, as we said in the preceding paragraph, that every substance that can be precipitated by HS, or in fact by any other reagent which he may be directed to employ, is *completely* removed thereby; this precaution, especially in the analysis of mixed compounds, is of the utmost importance, and must be strictly adhered to, otherwise the most perplexing results, and the most inextricable confusion will be the consequence. Great cleanliness on the part of the operator, and purity of the reagents, are, for the same reasons, indispensable for carrying out an analysis to a successful issue.

The student is strongly recommended never to omit examining the compound to be analyzed according to the directions set forth in Tables I—A, B, C, D, E; Table II—A, B, and Table III., experience having afforded undeniable proofs of this being the best, shortest, and safest plan.

GENERAL RULES RESPECTING THE EXAMINATION FOR ACIDS.

Before testing for acids it is necessary in many instances to remove from the liquor, which is to be so tested, all the bases which it may contain except the alkalies and alkaline earths, because their presence would interfere with, or completely mask the action of the reagents employed for the separating or identifying acids, since many bases are precipitated also by these reagents. If, therefore, the examination for bases has shown the presence of a base, or metallic oxyde which can be precipitated by sulphuretted hydrogen from their acid solution, it will be sufficient to pass a stream of that gas through the acidified liquor to supersaturation, filter, and boil the liquor in order to expel the HS. If the base or metallic oxyde found in the examination for bases has shown the presence of a base or metallic oxyde which, though not precipitable by HS, can be precipitated by NH_4S, it will be sufficient to supersaturate the neutralized liquor with NH_4S, filter, acidify the filtrate with HCl, or with NO_5, boil and filter in order to expel the HS, and separate the sulphur liberated. If the liquor contains two or more of these various bases or metallic oxydes, the operator passes first a stream of HS through the acid liquor under examination until it ceases to produce a precipitate; the liquor is then filtered, and the filtrate being then supersaturated with NH_3 is next to be treated by NH_4S as long as a precipitate is produced by this reagent; the liquor is again filtered, and the filtrate which can now contain nothing else than alkalies and alkaline earths, being supersaturated by HCl, or by NO_5, and boiled until all odour of HS has vanished, is then in a fit condition for a systematic examination of both organic and inorganic acids.

If, after having acidified the liquor with HCl, no acid has been found, then another portion of the liquor to which, of course, no HCl has been added, being acidified with NO_5, is then tested for HCl with nitrate of silver, and other appropriate reagents.

If the compound to be analyzed is insoluble in water, but soluble in acids, and if the preliminary examination has shown the presence of HCy—HBr—or HI, it may be reduced to a very fine powder, and at once boiled in NaO,CO_2 by which treatment the base of the cyanide, bromide, or iodide is left in an insoluble state either as a hydrated oxyde, or as a carbonate, whilst the acid of the compound combining with the soda, remains in solution in the liquid in which it may be subsequently identified by first neutralizing it with NO_5 and testing with the proper reagents.

All the organic acids are decomposed by boiling with NaO,CO_2, and are thereby converted into alkaline salts, which are then soluble in water, and in the solution of which they may, therefore, be easily detected by testing with the appropriate reagents.

CLASSIFICATION OF METALLIC OXYDES, AND OF ACIDS BOTH ORGANIC AND INORGANIC, IN REFERENCE TO THEIR DEPORTMENT, WITH CERTAIN REAGENTS ON WHICH THE METHOD OF SYSTEMATIC ANALYSIS, DESCRIBED IN THE TABLES, IS FOUNDED.

METALLIC OXYDES.

FIRST DIVISION.

METALLIC OXYDES PRECIPITATED FROM THEIR ACID SOLUTIONS BY HS:—

Oxyde of silver	AgO	PRECIPITATES.
Suboxyde of mercury	Hg_2O	
Peroxyde of mercury	HgO	
Oxyde of lead	PbO	Black.
Oxyde of bismuth	BiO	
Oxyde of copper	CuO	
Peroxyde of gold	AuO_3	
Peroxyde of platinum	PtO_2	
Sesquioxyde of antimony	Sb_2O_3	Orange red.
Protoxyde of tin	SnO	Chocolate brown.
Peroxyde of iron	Fe_2O_3	White (sulphur.)
Sulphurous acid	SO_2	
Peroxyde of tin	SnO_2	Yellow.
Arsenious acid	AsO_3	
Arsenic acid	AsO_5	
Oxyde of cadmium	CdO	

Besides these oxydes to which the ordinary Tables refer, the following are also precipitated by HS from their acid solutions:—

Oxyde of palladium	Pd_2O	Black.
Oxyde of molybdenum	MoO	Blackish brown.
Osmic acid	O_3O_4	Brownish black.
Suboxyde of copper	Cu_2O	Brown.
Peroxyde of iridium	IrO_2	
Peroxyde of molybdenum	MoO_2	
Protoxyde of platinum	PtO	
Sesquioxyde of rhodium	R_2O_3	
Oxyde of tellurium (Tellurious acid)	TeO_2	
Molybdic acid	MoO_3	
Oxyde of osmium	OsO_2	Brownish yellow.
Antimonic acid	SbO_5	Orange yellow.
Antimonious acid	SbO_3	
Chromic acid	CrO_3	Greenish colour.
Selenious acid	SeO_3	Lemon yellow.
Vanadic acid	VO_3	Greyish brown.

The first division may be subdivided into two groups as follows:—

First Group.

Metallic oxydes precipitated by HS from their ACID solutions, but not from their alkaline solutions, because their sulphurets are SOLUBLE in alkaline sulphurets; wherefore the precipitate produced in their acid solutions by HS is RE-DISSOLVED by NH_4S; they are,—

Peroxyde of gold	AuO_3	Black.
Oxydes of platinum	PtO, PtO_2	Black.
Oxydes of tin	SnO	Brown.
	SnO_2	Yellow.
Oxydes of arsenic	AsO_3, AsO_5	Yellow.
Oxydes of antimony	Sb_2O_3, SbO_3, SbO_5	Orange red.
Peroxyde of iridium	IrO_2	Brown.
Oxydes of molybdenum	MoO, MoO_2, MoO_3	Brown.
Oxyde of tellurium (Tellurious acid.)	TeO_2	Brown.
Selenious acid	SeO_2	Lemon yellow.
Vanadic acid	VO_3	Greyish brown.

The white precipitate produced in solutions of sulphurous and chromic acid being sulphur, is also soluble in NH_4S.

Second Group.

Metallic oxydes precipitated from their ACID, NEUTRAL, or ALKALINE solutions by HS, because their sulphurets are INSOLUBLE in alkaline sulphurets; wherefore the precipitate produced in their solutions by HS is not RE-DISSOLVED by NH_4S; they are,—

Oxyde of silver	AgO	Black.
Oxydes of mercury	Hg_2O, HgO	
Protoxyde of lead	PbO	
Oxyde of bismuth	BiO	
Oxydes of copper	Cu_2O, CuO	
Oxyde of palladium	PdO	
Peroxyde of iron	Fe_2O_3	White (the precipitate is S.)
Oxyde of cadmium	CdO	Yellow.
Oxydes of osmium	OsO_2	Brownish yellow
	OsO_4	Brownish black.
Sesquioxyde of rhodium	Rh_2O_3	Brown.

SECOND DIVISION.

METALLIC OXYDES NOT PRECIPITATED FROM THEIR ACID SOLUTIONS BY HS:—

Protoxyde of iron	FeO
Peroxyde of iron (white precipitate of S)	Fe_2O_3
Oxyde of nickel	NiO
Oxyde of cobalt	CoO
Protoxyde of manganese	MnO
Sesquioxyde of chromium	Cr_2O_3
Oxyde of zinc	ZnO
Alumina	Al_2O_3
Baryta	BaO
Strontia	StO
Lime	CaO
Magnesia	MgO
Potash	KO
Soda	NaO
Ammonia	NH_3

To which must be added the more rare compounds,—

Protoxyde of cerium	CeO
Glucina	GlO
Tantalic acid	TaO_3
Titanic acid	TiO_2
Thorina	ThO
Yttria	YO
Zirconia	ZrO
Chromic acid	CrO_3
Sesquioxyde of manganese	Mn_2O_3
Manganic acid	MnO_3
Permanganic acid	Mn_2O_7
Protoxyde of uranium	UO
Sesquioxyde of uranium	U_2O_3
Lithia	LiO

These compounds may be farther subdivided into four other groups, as follows:—

Third Group.

Compounds not precipitated from their acid solutions by HS, but PRECIPITATED from their solutions previously neutralized by NH_3 *in the state of sulphurets;* they are,—

Oxydes of iron	FeO, Fe_2O_3	Black precipitate.
Oxyde of nickel	NiO	
Oxyde of cobalt	CoO	
Oxydes of uranium	UO, U_2O_3	Brown precipitate.

Oxydes of manganese	MnO, Mn_2O_3, MnO_3, Mn_2O_7	Flesh red.

Fourth Group.

Metallic oxydes not precipitated from their acid solutions by HS, but PRECIPITATED from their solutions previously neutralized by NH_3 in the state of *hydrated oxydes;* they are,—

Oxydes of chromium	Cr_2O_3, CrO_3	Greenish precipitate.
Alumina	Al_2O_3	White precipitate.
Glucina	GlO	
Tantalic acid	TaO_3	
Titanic acid	TiO_2	
Thorina	ThO	
Yttria	YO	
Zirconia	ZrO	
Oxydes of cerium	CeO, Ce_2O_3	

Fifth Group.

Bases NOT PRECIPITATED from acid solutions by HS, NOR from their neutral solutions by NH_4S, but PRECIPITATED by NH_4O,CO_2 (and other alkaline carbonates), and by $\overline{(2NaO)PhO_5}$,—

Baryta	BaO	White precipitate.
Strontia	StO	
Lime	CaO	
Magnesia *	MgO	

Sixth Group.

Bases not precipitated by any of the preceding reagents, namely, HS, nor by NH_4S, nor by NH_4O,CO_2, or other alkaline carbonates, nor by $\overline{(2NaO,)PhO_5}$,—

Ammonia	NH_3
Potash	KO
Soda	NaO
Lithia	LiO

* Magnesia is not precipitated by NH_4O,CO_2, but is precipitated by the other alkaline carbonates.

CLASSIFICATION OF ACIDS.

Acids, whether inorganic or organic, are also divided into groups, according to their deportment with certain reagents. The reagents which serve thus to separate acids into groups in the systematic analysis followed in the Tables, are chloride of barium (BaCl) and nitrate of silver (AgO,NO_5) for the inorganic acids; chloride of calcium (CaCl) and sesquichloride of iron (Fe_2Cl_3) for the organic acids.

INORGANIC ACIDS.

First Group.

Inorganic acids precipitated by BaCl:—

Chromic acid	CrO_3	Yellow precipitate.
Arsenious acid	AsO_3	White precipitate.
Arsenic acid	AsO_5	
Sulphuric acid	SO_3	
Sulphurous acid	SO_2	
Silicic acid	SiO_3	
Hydrofluoric acid	HFl	
Phosphoric acid	PhO_5	
Phosphorous acid	PhO_3	
Boracic acid	BO_3	
Carbonic acid	CO_2	
Bromic acid	BrO_5	
Iodic acid	IO_5	
Hyposulphurous acid	S_2O_2	
Hyposulphuric acid	S_2O_5	
Selenic acid	SeO_3	
Selenious acid	SeO_2	
Vanadic acid	VaO_3	
Osmic acid	OsO_4	
Antimonic acid	Sb_2O_5	
Antimonious acid	Sb_2O_4	
Tungstic acid	WO_3	
Molybdic acid	MbO_3	
Telluric acid	TeO_3	

Second Group.

Inorganic acids not precipitated by BaCl, but precipitated by AgO,NO_5:—

Hydrochloric acid	HCl	White.
Hydrocyanic acid	HCy	
Hydrosulphocyanic acid	CyS,H	
Hydriodic acid	HI	Yellowish white.
Hydrobromic acid	HBr	
Nitrous acid	NO_3	
Hyposulphurous*	S_2O_2	White, becoming black.
Hydrosulphuric acid	HS	Black.
Hydroselenic	SeH	

Third Group.

Inorganic acids not precipitated by BaCl, nor by AgO,NO_5:—

Nitric acid	NO_5
Chloric acid	ClO_5
Perchloric acid	ClO_7
Hypochlorous acid	ClO

* Hyposulphurous acid is precipitated by BaCl in moderately strong solutions.

ORGANIC ACIDS.

First Group.

Organic acids precipitated by CaCl:—

Tartaric acid $C_8H_4O_{10},2HO$ or $\overline{T},2HO$	White.
Racemic Acid $C_4H_2O_5$ or $\overline{R},HO$	
Oxalic acid C_2O_3HO or $\overline{O},HO$	
Tannic acid $C_{18}H_5O_9,3HO$ or $\overline{Qt},3HO$	
Meconic acid $C_{14}HO_{11},3HO$ or $\overline{Me},3HO$	
Citric acid $C_{12}H_5O_{11},3HO$ or $\overline{Ci},3HO$ by boiling only	
Malic acid $C_2H_4O_8,2HO$ or $\overline{M},2HO$ by adding alcohol	
Gallic acid $C_7HO_3,3HO$, or $\overline{G},3HO$	Black.

Second Group.

Organic acids not precipitated by CaCl, but precipitated by Fe_2Cl_3 from their neutral solutions:—

Succinic acid $C_4H_2O_3,HO$ or $\overline{S},HO$	Reddish Brown precipitate.
Benzoic acid $C_{14}H_5O_3,HO$ or $\overline{Bz},HO$	

Third Group.

Acetic acid $C_4H_3O_3,HO$ or $\overline{A},HO$.
Formic acid C_2HO_3,HO or $\overline{Fo}O_3,HO$.
Uric acid $C_{10}H_4N_4O_5,HO$ or $\overline{U},HO$.

ALPHABETICAL LIST AND EXPLANATION OF THE SYMBOLS USED IN THE TABLES.

A.

$\overline{A},HO$	Acetic acid.
Ag	Silver.
AgBr	Bromide of silver.
AgCl	Chloride of silver.
AgCy	Cyanide of silver.
AgI	Iodide of silver.
AgO	Oxyde of silver.
AgO,NO_5	Nitrate of silver.
Al	Aluminium.
Al_2O_3	Alumina.
As	Arsenic.
AsH_3	Arseniuretted hydrogen.
AsO_3	Arsenious acid.
AsO_5	Arsenic acid.
AsS_2	Bisulphuret of arsenic. Realgar.
AsS_3	Trisulphuret of arsenic. Orpiment.
AsS_5	Pentasulphuret of arsenic.
Au	Gold.
$AuCl_3$	Terchloride of gold.
AuO_3	Oxyde of gold.

B.

Ba	Barium.
BaCl	Chloride of barium.
BaO	Baryta.
BaO,CrO_3	Chromate of baryta.
BaO,NO_5	Nitrate of baryta.
BaO,SO_3	Sulphate of baryta.
BFl_3	Fluoride of boron.
Bi	Bismuth.
BiO	Oxyde of bismuth.
$Bi_2O_3,3NO_5,10HO$	Neutral nitrate of bismuth.
Bi_2O_3,NO_5,HO	Basic nitrate of bismuth.
BO_3	Boracic acid.
Br	Bromine.
BrO_5	Bromic acid.
$\overline{Bz},HO$	Benzoic acid.

C.

C	Carbon.
C_2H_4	Light carburetted hydrogen.
C_2HO_3,HO	Formic acid.
$C_2H_4O_8,2HO$	Malic acid.
C_2O_3,HO	Oxalic acid.
$C_4H_3O_3,HO$	Acetic acid.
C_4H_4	Olefiant gas.
C_4H_6As Cacodyle or Acetyle of Arsenic	
$C_4H_6O_2$	Alcohol.
$C_4H_2O_3,HO$	Succinic acid.
$C_7HO_3,3HO$	Gallic acid.
$C_8H_4O_{10}$	Racemic acid.
$C_8H_4O_{10},2HO$	Tartaric acid.
$C_{10}H_4N_4O_5,HO$	Uric acid.
$C_{12}H_5O_{11},3HO$	Citric acid.
$C_{14}HO_{11},3HO$	Meconic acid.
$C_{14}H_5O_3,HO$	Benzoic acid.
$C_{18}H_5O_9,3HO$	Tannic acid.
Ca	Calcium.
CaCl	Chloride of calcium.
CaFl	Fluoride of calcium.
CaO	Lime.
CaO,SO_3	Sulphate of lime.
Cd	Cadmium.
CdO	Oxyde of cadmium.
Ce	Cerium.
CeO	Oxyde of cerium.
$\overline{Ci},3HO$	Citric acid.
Cl	Chlorine.
ClO_x	Hypochlorous acid.
ClO_5,HO	Chloric acid.
C_2N	Cyanogen.
Co	Cobalt.
CoO	Oxyde of cobalt.
Co_2O_3	Sesquioxyde of cobalt.
CoO,NO_5	Nitrate of cobalt.
CO	Carbonic oxyde.
CO,Cl	Chloroxycarbonic acid.
CO_2	Carbonic acid.
Cr	Chromium.
$CrCl_3,2CrO_3$	Chromate of chloride of chromium.
Cr_2O_3	Sexquioxde of chromium.
CrO_3	Chromic acid.
Cr_2O_3,SO_3	Sulphate of sesquioxyde of chromium.
CSy	Sulphocyanogen.
Cu	Copper.
CuO	Protoxyde of copper.
CuO,SO_3	Sulphate of copper.
CuO,NO_5	Nitrate of copper.
Cy	Cyanogen.
CyS	Sulphocyanogen.
CyS_2,H	Hydrosulphocyanic acid.

* ClO_x . . . Chlorous Acid

F.

Fe	Iron.
Fe_2Cl_3	Perchloride of iron.
FeO	Protoxyde of iron.
FeO,SO_3	Protosulphate of iron.

* CyO,HO . . Cyanic Acid
$Cy_2O_2,2HO$ . . Fulminic Acid

Fe_2O_3 . . Peroxyde of iron.
Fe_2O_3,HO . Hydrated peroxyde of iron.
Fl . . Fluorine.
$Fo O_3,HO$. } Formic acid.
$\overline{Fo},HO$. }

G.

$\overline{G},3HO$. Gallic acid
Gl_2O_3 . . Glucina.

H.

H . . Hydrogen.
H_2Cy_3Fe . Hydroferrocyanic acid.
$H_3Cy_6Fe_2$. Hydroferricyanic acid.
HBr . . Hydrobromic acid.
HCl . . { Hydrochloric acid. Muriatic acid.
H_2Cfy . . Hydroferrocyanic acid.
HCy . . Hydrocyanic acid.
HFl . Hydrofluoric acid.
$HFl,SiFl_2$. Hydrofluosilicic acid.
Hg . . Mercury.
HgCl . . { Bichloride of mercury. Protochloride of mercury. Perchloride of mercury. Corrosive sublimate.
Hg_2Cl . . { Protochloride of mercury. Subchloride of mercury. Calomel.
HgCy . . Cyanide of mercury.
HgI . . Iodide of mercury.
HgO . . Oxyde of mercury.
Hg_2O . . Suboxyde of mercury.
Hg_2O,NO_5 . Subnitrate of mercury.
HgS . . { Bisulphuret of mercury. Protosulphuret of mercury. Cinnabar. Vermillon.
Hg_2S . . { Protosulphuret of mercury. Subsulphuret of mercury.
HI . . Hydriodic acid.
HS . . { Sulphuretted hydrogen. Hydrosulphuric acid.

I.

I . . . Iodine.
IO_5 . . . Iodic acid.
Ir . . . Iridium.

K.

K . . Potassium.
KBr . . Bromide of potassium.
KCl . . Chloride of potassium.
$K_2Cy_3Fe,3HO$ } Ferrocyanide of potassium.
K_2Cfy . . }
$K_3(2Cfy)$. } Ferricyanide of potassium.
$K_3Cy_6Fe_2$. }
KCy . . Cyanide of potassium.
KCSy . . } Sulphocyanide of potassium.
K_2CyS . . }
KC_2NS_2 . }
KI . . Iodide of potassium.

KO . . Potash.
$KO,\overline{A}$ . . Neutral acetate of potash.
$(2KO)C_8H_4O_{10}$. Neutral tartrate of potash.
$KO,HO,C_8H_4O_{10}$. Acid tartrate of potash.
KO,ClO_5 . Chlorate of potash.
KO,CO_2 . Carbonate of potash.
$KO,2CO_2$. Bicarbonate of potash.
KO,CrO_3 . Chromate of potash.
$KO,2CrO_3$. Bichromate of potash.
KO,NO_5 . Nitrate of potash.
KO,SO_3 . Sulphate of potash.
$KO,2SO_3$. Anhydrous bisulphate of potash.
$KO,2SO_3HO$. Hydrated bisulphate of potash.
$KO,Sb_2O_5,5HO$. Antimoniate of potash.
$(2KO)\overline{T}$. Neutral tartrate of potash.
$KO,HO,\overline{T}$. Acid tartrate of potash.
KO,U_2O_3 . Uraniate of potash.
KS . . . Sulphuret of potassium.

M.

$\overline{M},2HO$. Malic acid.
$\overline{Me},3HO$. Meconic acid.
Mg . . Magnesium.
MgO . . Magnesia.
MgO,SO_3 . Sulphate of magnesia.
Mn . . Manganese.
MnO . . Protoxyde of manganese.
Mn_2O_3 . . Sesquioxyde of manganese.
MnO_2 . . { Peroxyde of manganese. Binoxyde of manganese. Deutoxyde of manganese.
MnO_3 . . Manganic acid.
Mn_2O_7 . . Permanganic acid.
Mo . . Molybdenum.
MoO . . Protoxyde molybdenum.
MoO_2 . . Deutoxyde molybdenum.
MoO_3 . . Molybdic acid.

N.

N . . Nitrogen.
Na . . Sodium.
NaCl . . Chloride of sodium.
NaO . . Soda.
$NaO,\overline{A}$ . . Acetate of soda.
NaO,CO_2 . . Carbonate of soda.
$NaO,2CO_2$ . . Bicarbonate of soda.
$(2NaO)HO,PhO_5$. Phosphate of soda.
$(2NaO)PhO_5$. Pyrophosphate of soda.
$NaO,\overline{2HO},PhO_5$. Acid phosphate of soda.
NaO,SO_2 . Sulphite of soda.
NaO,SO_3 . Sulphate of soda.
NaO,S_2O_2 . Hyposulphite of soda.
NH_3 . . { Ammonia.
NH_4O . . }
NH_4Cl . { Salammoniac. Chloride of ammonium.
NH_4CyS_2 . Sulphocyanide of ammonium.
NH_4O,CO_2 . Carbonate of ammonia.
$\overline{(2NH_4O)3CO_2}$. Sesquicarbonate of ammonia.
NH_4O,NO_5 . Nitrate of ammonia.

$NH_4O,\overline{O}$ . . Oxalate of ammonia.
NH_4S . . Hydrosulphuret of ammonia.
NH_4S_4 . . Persulphuret of ammonia.
Ni . . Nickel.
NiO . . Protoxyde of nickel.
Ni_2O_3 . . Sesquioxyde of nickel.
NO . . { Protoxyde of nitrogen. Laughing gas.
NO_2 . . Nitric oxyde.
NO_3 . . Nitrous acid.
NO_4 . . Hyponitric acid.
NO_5 . . Nitric acid.

O.

O . . Oxygen.
$\overline{O},HO$ . . Oxalic acid.
Os . . Osmium.
OsO_4 . . Osmic acid.

P.

Pb . . Lead.
PbCl . . Chloride of lead.
PbO . . Protoxyde of lead.
PbO_2 . . { Peroxyde of lead. Plumbic acid.
$PbO,\overline{A}$ . . Neutral acetate of lead.
$(3PbO),\overline{A}$. Tribasic acetate of lead.
$(6PbO)\overline{A}$. Hexabasic acetate of lead.
$(3PbO)2\overline{A}$. Sesquibasic acetate of lead.
$(2PbO)PbO_2$. { Plumbate of lead. Peroxyde of lead. Red lead.
PbO,CrO_3 . Chromate of lead.
PbO,NO_5 . Nitrate of lead.
PbO,SO_3 . Sulphate of lead.
Pd . . Palladium.
Ph . . Phosphorus.
PhH_3 . . Phosphuretted hydrogen.
PhO . . Hypophosphorous acid.
PhO_3 . . Phosphorous acid.
PhO_5 . . Phosphoric acid.
Pt . . Platinum.
$PtCl_2$ . . { Chloride of platinum. Bichloride of platinum.

Q.

$\overline{Qt},3HO$. Tannic acid.

R.

$\overline{R}$ . . Racemic acid.
Rh . . Rhodium.

S.

S . . . Sulphur.
Sb . . Antimony.
SbH_3 . . Antimonietted hydrogen.
Sb_2O_3 . . Sesquioxyde of antimony.
Sb,O_5 . . Antimonic acid.

Sb_2S_3 . . { Protosulphuret of antimony. Sesquisulphuret of antimony.
Sb_2S_5 . . Persulphuret of antimony.
Sb_2Cl_3 . . Sesquichloride of antimony.
$Sb_2Cl_3(2Sb_2O_3)$ { Basic chloride or oxychloride of antimony.
Sb_2Cl_5 . . Perchloride of antimony.
SbO,Sb_2O_5 . { Antimoniate of oxyde of antimony.
Se . . Selenium.
SeO_2 . . Selenious acid.
SeO_3 . . Selenic acid.
$\overline{S},HO$ . . Succinic acid.
$SiFl_3$ . . Fluoride of silicium.
$(2SiFl_3)3HFl$. Hydrofluosilicic acid.
SiO_3 . . { Silicic acid. Silica.
Sn . . Tin.
SnCl . . Chloride of tin.
SnO . . Protoxyde of tin.
SnO_2 . . Binoxide of tin.
SO_3HO . { Concentrated sulphuric acid (oil of vitriol).
SO_3 . . Anhydrous sulphuric acid.
SO_2 . . Sulphurous acid.
S_2O_2 . . Hyposulphurous acid.
S_2O_5 . . { Hyposulphuric acid. Dithionic acid.
S_4O_5 . . Tetrathionic acid.
S_5O_5 . . Pentathionic acid.
St . . Strontium.
StO . . Strontia.
StO,NO_5 . Nitrate of strontia.
StO,SO_3 . Sulphate of strontia.

T.

$\overline{T},2HO$. Tartaric acid.
Ta . . Tantalum.
Te . . Tellurium.
TeO_2 . . Tellurious acid.
Ti . . Titanium.
TiO . . Oxyde of Titanium.
TiO_2 . . Titanic acid.

U.

U . . Uranium.
$\overline{U},HO$ . . Uric acid.

W.

W . . Tungsten.
WO_2 . . Oxyde of Tungsten.
WO_3 . . Tungstic acid.

Y.

YO . . Yttria.

Z.

Zn . . Zinc.
ZnO . . Oxyde of zinc.
Zr . . Zirconium.
Zr_2O_3 . . Zirconia.

CLASSIFICATION OF THE METALS.

The metals have been divided into six sections by MM. Thénard and Regnault as follows:—

First Section.

The metals of the first section are those which absorb oxygen, even at the highest temperature, decompose water in the cold, and in so doing disengage hydrogen and produce strongly alkaline oxydes. They are—

Potassium,	Barium,
Sodium,	Strontium,
Lithium,	Calcium.

Second Section.

The metals of the second section absorb oxygen at a very high temperature, but decompose water only when heated from 212° to 400° Fahr., and sometimes only at a dark red heat. They are –

Glucinium,	Lanthanum,
Aluminium,	Didymium,
Magnesium,	Manganese,
Zirconium,	Uranium,
Thorinium,	Pelopium,
Yttrium,	Niobium,
Cerium,	Erbium and Terbium.

Third Section.

The metals of the third section absorb oxygen at a high temperature; they decompose water only at a dark red heat, or in the cold with the help of an acid. They are —

Iron,	Cadmium,
Cobalt,	Chromium,
Nickel,	Vanadium.
Zinc,	

Fourth Section.

The metals of the fourth section absorb oxygen at a high temperature; they decompose water only at a red heat, and do not decompose it at all in the cold, even with the help of an acid. They are—

Tungsten,	Titanium,
Molybdenum,	Tin,
Osmium,	Antimony,
Tantalum.	

Fifth Section.

The metals of the fifth section decompose aqueous vapour only slowly, and at a very high temperature; their oxydes cannot be reduced by heat. They are

Bismuth, Lead, Copper.

Sixth Section.

The metals of the sixth section are those called *noble*. They do not decompose water, and their oxydes are reduced by heat. They are

Mercury,	Palladium,
Silver,	Ruthenium,
Rhodium,	Platinum,
Iridium,	Gold.

CLASSIFICATION OF METALLIC OXYDES.

Next to the salts, metallic oxydes form the most numerous class of compounds; they result, of course, from the combination of metals with oxygen. There are upwards of one hundred oxydes which, according as they act as bases towards acids, or as acids towards powerful bases, or as neither acids or bases, have been divided into corresponding sections as hereunder.

First Section.

BASIC METALLIC OXYDES, OR BASES.

The oxydes of this section combine with acids to form salts. The bases or oxydes of the metals of the first section have an alkaline reaction on test papers; and they appear in the following order in Pelouze and Frémy's *Traité de Chimie Générale.*

Alumina	Al_2O_3
Sesquioxyde of antimony	Sb_2O_3
Suboxyde of silver	Ag_2O
Protoxyde of silver	AgO
Sesquioxyde of bismuth	Bi_2O_3
Oxyde of cadmium	CdO
Lime	CaO
Protoxyde of cerium	CeO
Sesquioxyde of cerium	Ce_2O_3
Protoxyde of chromium	CrO
Sesquioxyde of chromium	Cr_2O_3
? Oxyde of cobalt, unknown composition. Dissolves in oxalic acid, and the solution is green.	
Oxyde of cobalt	CoO
Sesquioxyde of cobalt	Co_2O_3
Soluble in acetic acid.	
Suboxyde of copper	Cu_2O
Protoxyde of copper	CuO
Protoxyde of tin	SnO
Protoxyde of iron	FeO
Sesquioxyde of iron	Fe_2O_3
Glucina	Gl_2O_3
Protoxyde of iridium	IrO
Binoxyde of iridium	IrO_2
Lithia	LiO
Baryta	BaO
Magnesia	MgO
Protoxyde of manganese	MnO
Sesquioxyde of manganese	Mn_2O_3
Suboxyde of mercury	Hg_2O
Protoxyde of mercury	HgO
Protoxyde of molybdenum	MoO
Binoxyde of molybdenum	MoO_2 ?
Oxyde of nickel	NiO
Protoxyde of osmium	OsO ?
Sesquioxyde of osmium	Os_2O_3
Binoxyde of osmium	OsO_2
Protoxyde of palladium	PdO
Protoxyde of platinum	PtO
Binoxyde of platinum	PtO_2
Protoxyde of lead	PbO
Potash	KO
Sesquioxyde of rhodium	Rh_2O_3
Soda	NaO
Strontia	StO
Protoxyde of titanium	TiO
Thorina	ThO
Protoxyde of uranium	UO
Sesquioxyde of uranium	U_2O_3
Yttria	YO
Binoxyde of vanadium	VO_2
Oxyde of zinc	ZnO
Oxyde of terbium	TeO
Oxyde of erbium	ErO

Second Section.

ACID OXYDES (METALLIC ACIDS).

The oxydes of this section have the property of neutralizing bases, and, like acids, to form with them salts which frequently have an acid reaction on test papers; they are,—

Alumina (aluminic acid)	Al_2O_3HO
Antimonious acid	Sb_2O_3HO
Antimonic acid	Sb_2O_5
Bismuthic acid	Bi_2O_5
Chromic acid	CrO_3
Perchromic acid	Cr_2O_7
Sesquioxyde of chromium (chromous acid)	Cr_2O_3,10HO
Cupric acid (unknown composition).	
Oxyde of copper	CuO,HO
Protoxyde of tin	SnO,HO
Stannic acid	SnO_2HO
Metastannic acid	Sn_5O_{10},10HO
Ferric acid	FeO_3
Binoxyde of iridium	IrO_2
Iridic acid	IrO_3 ?
Manganic acid	MnO_3
Permanganic acid	Mn_2O_7
Peroxyde of manganese	MnO_2 ?
Molybdic acid	MoO_3
Aurous acid (suboxyde of gold)	Au_2O
Auric acid (sesquioxyde of gold)	Au_2O_3
Osmious acid	OsO_3
Osmic acid	OsO_4
Binoxyde of palladium	PdO_2 ?
Binoxyde of platinum	PtO_2
Protoxyde of lead	PbO,HO
Plombic acid	PbO_2
Tantalic acid	Ta_2O_3
Oxyde of titanium	TiO
Titanic acid	TiO_2
Tungstic acid	WO_3
Oxyde of tungsten	WO_2 ?
Uranic acid	U_2O_3
Vanadous acid	VO_2
Vanadic acid	VO_3
Oxyde of zinc	ZnO

Third Section.

INDIFFERENT OXYDES,

or metallic oxydes which do not combine with either acids or bases. They are—

Peroxyde of silver	AgO_2
Binoxyde of barium	BaO_2
Binoxyde of calcium	CaO_2
Sesquioxyde of cobalt	Co_2O_3
Peroxyde of copper	CuO_2
Sesquioxyde of iridium	Ir_2O_3
Peroxyde of manganese	MnO_2
Sesquioxyde of nickel	Ni_2O_3
Binoxyde of osmium	OsO_2
Suboxyde of lead	Pb_2O
Suboxyde of potash	K_2O
Peroxyde of sodium	Na_2O_3
Peroxyde of potassium	KO_2
Protoxyde of rhodium	RhO
Suboxyde of sodium	Na_2O
Peroxyde of strontium	StO_2
Protoxyde of tantalum	TaO
Oxyde of tungsten	WO_2
Suboxyde of uranium	U_4O_3
Protoxyde of vanadium	VO
Suboxyde of zinc	Zn_2O
Peroxyde of zinc	ZnO_2

Fourth Section.

SALINE OXYDES

are compound oxydes resulting from the combination of two oxydes of a same metal, one of which

acting as an acid upon the other, which acts as a base. For example, the compound known under the name of red lead, Pb_3O_3, may be considered as a combination of binoxyde of lead, PbO_2 (metallic acid, which may be called plumbic acid) with protoxyde of lead, PbO, and therefore may be called *plumbate of lead;* they are—

Antimoniate of protoxyde of Antimony	(Sb_2O_3,Sb_2O_5)
Bismusthate of bismuth	Bi_2O_3,Bi_2O_5
Chromate of protoxyde of chromium	CrO,CrO_3
Chromate of sesquioxyde of chromium	Cr_2O_3,CrO_3
Stannate of protoxyde of tin	SnO,SnO_2
Metastannate of protoxyde of tin	SnO,Sn_5O_{10}
Magnetic oxyde of iron	FeO,Fe_2O_3
Oxyde of iron (scales from red-hot iron	$(FeO)^4,Fe_2O_3$
	$(FeO)^6.Fe_2O_3$
Red oxyde of manganese	Mn_2O_3,MnO
Oxydes of cobalt	CoO,Co_2O_3
	$(CoO)^4,CoO_2$
Molybdate of molybdenum	$(MoO_3)^4,MoO_2$
	$(MoO_3)^2,MoO_2$
Plumbate of protoxyde of lead (minium)	PbO_2PbO
	$PbO_2,2PbO$
	$PbO_2,3PbO$
	$PbO_2,5PbO$
Oxydes of rhodium	$(RhO_3),Rh_2O_3?$
	$(RhO_2),Rh_2O_3?$
	RhO,Rh_2O_3
Titanate of titanium	TiO_2,TiO
Blue oxyde of tungsten	WO_2,WO_3
Oxyde of uranium	$U_2O_3,(UO_2)$
	UO,U_2O_3
Vanadate of oxyde of vanadium	VO,VO_3

Action of the Air.—Several metallic oxydes absorb oxygen when left exposed to the air, at the ordinary temperature, or at a red heat. Very few, however, absorb oxygen if the atmosphere is perfectly dry, but if moist, they may absorb it, and pass to a higher degree of oxydization. The following absorb oxygen at the ordinary temperature :—

Protoxyde of iron	FeO	becomes	Hydrate of sesquioxyde of iron	Fe_2O_3,HO
Protoxyde of manganese	MnO	,,	Hydrate of sesquioxyde	Mn_2O_3,HO
Protoxyde of cobalt	CoO	,,	Hydrate of sesquioxyde	Co_2O_3,HO
Protoxyde of molybdenum	MoO	,,	Molybdate of molybdenum	$(MoO_3)^2MoO_2$?
Binoxyde of molybdenum	MoO_2?	,,	Molybdic acid	MoO_3
Suboxyde of copper	Cu_2O	,,	Hydrate of protoxyde	CuO,HO
Protoxyde of titanium	TiO	,,	Titanic acid	TiO_2

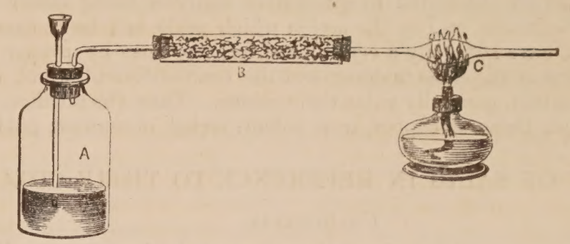
At a red heat the following absorb oxygen, and pass to a higher degree of oxydization :—

Protoxyde of barium	BaO	becomes	Binoxyde of barium	BaO_2
Protoxyde of potassium	KO	,,	Peroxyde of potassium	KO_2
Protoxyde of sodium	NaO	,,	Peroxyde of sodium	Na_2O_3
Protoxyde of manganese	MnO	,,	Peroxyde of manganese	MnO_2
Protoxyde of iron	FeO	,,	Peroxyde of iron	Fe_2O_3
Protoxyde of tin	SnO	,,	Peroxyde of tin	SnO_2
Protoxyde of molybdenum	MoO	,,	Molybdic acid	MoO_3
Binoxyde of molybdenum	MoO_2?	,,	Molybdic acid	MoO_3
Oxyde of tungsten	WO_2	,,	Tungstic acid	WO_3
Oxyde of titanium	TiO	,,	Titanic acid	TiO_2
Suboxyde of copper	Cu_2O	,,	Peroxyde of copper	CuO
Protoxyde of lead	PbO	,,	Minium	PbO_2,PbO
Suboxyde of mercury	Hg_2O	,,	Peroxyde of mercury	HgO

Action of Hydrogen.— At the ordinary temperature, hydrogen has no action upon metallic oxydes, but at a red heat it may decompose certain oxydes, forming water with their oxygen, and reducing them to the metallic state. The oxydes of the metals of the two first sections (see page 4), however, cannot be thus reduced, neither can it reduce oxyde of chromium of the third section. But though hydrogen cannot reduce the oxydes of the metals of the two first sections to the metallic state, yet the peroxydes of these metals, and also peroxyde of manganese, are brought by it to a lower degree of oxydization, that is to say, to the state of protoxyde.

Those of the metals of the last section (see page 4), are immediately reduced by it, at a very moderate heat.

When hydrogen is employed to reduce a metallic oxyde, the operator knows that the reduction is complete when water ceases to be condensed in the tube. The following figure represents the apparatus :—



A is a flask for disengaging hydrogen; B is a tube filled with fused chloride of calcium; C is a glass bulb, in which the oxyde to be reduced is put, and in which it is brought to a red heat by an argand spirit-lamp. Care must be taken to wait until all the air of the bottle has been expelled, before applying the spirit-lamp, or else the apparatus might explode.

Berzelius says, that all the metals, the affinity of which for oxygen is less than iron, are reduced by hydrogen, even peroxyde of iron; but that oxyde of zinc, of cerium, of titanium, of manganese, and of chromium, are not reduced, which is not correct. I have repeatedly reduced oxyde of zinc at a red heat, by a current of hydrogen, and not only can oxyde of zinc be thus reduced, but even the ore of that metal called calamine (carbonate of zinc). The metal thus obtained is always pure.

Action of Carbon.—Carbon acts upon metallic oxydes like hydrogen, but with more energy; they are all reduced by it, except those of the two first sections (page 4). In reducing the oxyde, the carbon becomes converted into carbonic oxyde, or carbonic acid, according to the degree of affinity of the metal for oxygen, the quantity of carbon employed, and the temperature required to operate the reduction. Those metallic oxydes which are easily reduced at a moderate heat, produce carbonic acid, mixed with oxyde of carbon; those which require a very high temperature, and a large excess of carbon, produce carbonic oxyde. The metals obtained by this method are generally combined with a small portion of carbon.

Action of Phosphorus.—At the ordinary temperature, phosphorus has no action upon metallic oxydes, but with the help of heat, they are all decomposed by it, except those of the second section (page 4). The oxydes of the fifth and sixth sections (page 4), produce phosphoric acid, and a metallic phosphuret; those of the other sections (except the second) produce a phosphate and a phosphuret. If water be present at the same time, the oxydes of the first section, when treated by phosphorus, produce a mixture of phosphate, and of hypophosphite, under disengagement of phosphuretted hydrogen, and hydrogen.

Action of Sulphur.—Sulphur, with the help of heat, acts upon the oxygen, and upon the metal of the oxyde. The oxydes of the first section (page 4), when exposed with sulphur, to a moderate heat, produce polysulphurets and hyposulphites; if the temperature be higher, the result is a polysulphuret and a sulphate. With the oxydes of the four last sections, the result is a sulphuret, sulphurous, or sulphuric acid.

Action of Chlorine.— When chlorine is made to react upon the aqueous solution of the oxydes of the first section (page 4), they are converted into hypochlorites, chlorates, or metallic chlorides, according to the degree of concentration, or of dilution of the solution, and the quantity of chlorine employed.

At about 212° Fahr. hydrate of potash, and of soda, KO,HO—NaO,HO are decomposed by chlorine, which displaces the oxygen, and they are converted into chloride of potassium, or of sodium.

Iodine and *bromine* act in a similar manner.

The oxydes of the other sections produce metallic chlorides by displacing the oxygen of the oxyde, except yttria, thorina, glucina, and alumina, which are decomposed by chlorine only under the influence of carbon, and of a red heat.

Action of Metals.—Certain metals react also upon metallic oxydes, by absorbing all the oxygen of the oxyde, and thus reducing it to the reguline state, or leaving it in the state of a pure metal of the oxyde, or else combining with it to form an alloy; the latter case occurs more generally when an excess of the metal is employed.

Sometimes, also, when a metal is put in contact with an oxyde, the latter is incompletely reduced, and brought to a lower degree of oxydization, which either remains in a free state, but which sometimes also combines with the other portion of the oxyde; or, lastly, the metal employed may have no action whatever upon the oxyde operated upon.

Potassium and sodium, by reason of their great affinity for oxygen, reduce a great number of oxydes, and especially those of the last sections.

GENERAL CHEMICAL PROPERTIES OF SALTS.

All the compounds which are submitted to qualitative analysis being either in the state of salts, or generally converted into salts at the very outset by the application of an acid, a few observations will now be offered on their characters, and on the action which acids and bases exercise upon them, as well as upon their mutual action upon each other.

Salts, for the most part, have generally a crystallized form, or may by proper management be made to assume it, and each crystallizable salt most generally crystallizes in a peculiar manner; yet there are a few salts which crystallize in the same manner, and the composition of which is nevertheless different; a few are in the gaseous, or in the liquid form, but all are heavier than water.

The base which salts contain, generally rules their colour. Thus the alkalies, earths, and a few metallic oxydes form colourless salts when the acids with which they are combined are colourless; but most metallic oxydes, for example those of copper, iron, cobalt, nickel, chromium, gold, &c., are coloured salts.

LIST OF SALTS IN REFERENCE TO THEIR COLOUR.

Colourless.

Salts of—Aluminium.[1]	Salts of—Cerium (protoxyde).[4]	Salts of—Potassium.[6]
Ammonia.[2]	Glucinium.	Silver.
Antimony (neutral).[3]	Lead.	Sodium.
Barium.	Lithium.	Strontium
Bismuth.	Magnesium.	Tellurium.
Cadmium.	Manganese (protoxyde).[5]	Tin.
Calcium.	Mercury.	Zinc.

White.

Barium.	Copper (anhydrous).[7]	Iron (peroxyde).
Cadmium.	Glucinium.	Lead.
Calcium.		

Yellow, or Orange.

Antimony.	Iridium.	Palladium.
Cerium (peroxyde).	Iron (peroxyde).	Platinum.
Chromates.	Mercury (basic).	Tellurium.
Gold.		

Greenish Yellow, or Green.[8]

Chromium.	Iron (protoxyde).	Copper.
Cobalt.[9]	Nickel.	Iridium (protoxyde).

Blue.

Chromium.	Cobalt (anhydrous).	Copper.

Pink.

Cobalt (dilute solution).	Manganese (sesquioxyde).

Red.

Cobalt.	Iridium (binoxyde).	Iron.
Mercury.	Bi-chromates.	

Amethyst.

Cerium (protoxyde).	Chromium.	Iridium (sesquioxyde).

Brown or Reddish Brown.

Cobalt.[9]	Iron.	Rhodium.	Chromates.

Black.

Iridium.	Iron.	Vanadium.

[1] Chloride of aluminium is greenish yellow.
[2] Ammonia-chloride of platinum is yellow.
[3] Some salts of antimony are yellowish.
[4] The salts of protoxyde of cerium have sometimes an amethyst colour.
[5] The salts of manganese are colourless only when perfectly pure, a trace of sesquioxyde is sufficient to give them a light pink colour.
[6] The double chloride of platinum and potassium is yellow.
[7] Perchloride of copper (CuCl) in the anhydrous state is yellowish-brown.
[8] The very concentrated solutions of the salts of cobalt which are contaminated by iron are green, otherwise they are blue.
[9] Dilute solutions of cobalt which contain iron are more or less brownish red.

LIST OF SALTS IN REFERENCE TO THEIR TASTE.

Astringent.

Salts of—	
Aluminum.	Slightly sweetish and acidulous.
Barium.	Disagreeable, salty, and bitter—most of them are poisonous.
Calcium.	Bitter, salty.
Iron.	Inky.
Strontium.	Bitter, salty.

Bitter.

Magnesium.	Disagreeable and different from other salts. The only salt of magnesia which has not a bitter taste is the citrate of that base.

Metallic.

Bismuth.	Very disagreeable.
Mercury.	
Silver.	
Tin.	
Cadmium.	Disagreeable, similar to zinc.
Antimony.	Feeble.
Cobalt.	Feeble, astringent.
Copper.	Astringent, disagreeable.
Gold.	Disagreeable.
Platinum.	

Styptic, or Astringent.

Thorinum.	Zinc.	Zirconium.

Sweetish Astringent.

Chromium.	Metallic afterwards.
Glucinium.	
Yttrium.	

Sweet, and then Acid and Styptic.

Cerium.
Lead.
Manganese.
Nickel, metallic after taste, but not strong.

Urinous and Bitter.

Ammonia, pungent, acrid.
Potassium.
Sodium.

Action of Water.—The affinity of salts for water varies, some salts being deliquescent, that is, abstracting moisture from the air, in consequence of which they become liquid; others which have less affinity for water undergo no change when the air is dry, but deliquesce in a moist atmosphere; others do not undergo any change, whatever may be the natural dryness or dampness of the air; other salts, again, at the ordinary temperature will sometimes, when exposed to a dry atmosphere, part with one equivalent of water of crystallization and will *effloresce*, in consequence of which they first become opaque from the outside, and ultimately fall into powder.

Salts dissolve in water when their *affinity* is greater than their *cohesion*. If, on the contrary, their cohesion is greater than their affinity, they are insoluble. According to Gay Lussac, solubility or solution is analogous to evaporation; the solution of a substance is, as it were, its evaporation in the menstruum which, similar to the tension of evaporated fluids, augments with the temperature: the difference between evaporation and solution being only, that in evaporation the molecules repulse each other sufficiently to maintain the substance in a gaseous state, whilst in solution the affinity of the solvent keeps these molecules equally distributed through it.

Water is said to be saturated when it has dissolved as much of a salt as it possibly can; but water which has thus dissolved as much of a salt as it can, that is to say, though saturated with a salt, may still be capable of dissolving another salt at a given temperature.

Generally speaking, salts are more soluble in hot than in cold water, except the following, which are more soluble in cold than in hot water:—

Sulphate of cerium.
Sulphate of Lanthanum.
Sulphate of soda.
Butyrate of lime.
Phosphoglycerate of barytes.
Phosphoglycerate of lime.
Phosphoglycerate of lime.
Aconitate of lime.
Stannate of soda.
Carbonate of magnesia (magnesia alba) $\overline{MgO,HO, (3\ MgO,CO_2)\ 3\ HO}$
Saccharate of lime.
Chloride of sodium (common salt) is as soluble in hot as in cold water
There are many salts, however, which are completely or almost insoluble in either cold or hot water.

Action of Heat.—Certain salts are not decomposed by heat, others are thus decomposed; such is the case, for example, with the chloride of magnesium and of aluminium, nitrate of lime, most ammoniacal salts, &c.

The amount of water of crystallization contained in a salt is sometimes modified by the temperature at which it is deposited from a solution; thus, borax produces in the cold crystals containing 10 equivalents of water, but above 158° Fahr. the crystals contain only 5 equivalents of water. Sulphate of soda deposits anhydrous crystals at a temperature above 89°·6 Fahr. below which they contain 10 equivalents of water of crystallization.

Salts which contain *water of crystallization* being subjected to heat, undergo the *watery fusion*, that is to say, they melt in their water of crystallization.

Salts which are anhydrous being exposed to a high temperature liquefy and undergo the *igneous fusion*, and, therefore, after the water of crystallization of a salt has been expelled, and the salt has become dry, it may undergo a second fusion (igneous fusion) by increasing the heat.

Certain salts when exposed to heat decrepitate, which is due sometimes to the expansion of the water interposed between the crystals, but sometimes also to an unequal expansion of the molecules of the salt, which causes a disruption of the crystals.

Some salts when heated in close vessels sublime, and condensing in the upper part of the vessel form regular crystals.

When a salt is decomposed by the application of heat, it may undergo four different reactions:—

1st. The oxyde or the acid of the salt, or both may separate without alteration.

2ndly. The oxyde of the salt may remain unaltered, whilst the acid is decomposed.

3rdly. The acid of the salt may distil or be disengaged without alteration, whilst the oxyde is decomposed.

4thly. Both the acid and the oxyde of the salt may be decomposed, but they, reacting upon each other, may produce compounds of quite a different kind, or else if heated in contact with the air, they, in losing their water, absorb oxygen or carbonic acid from the air, and become thus converted into carbonates, or pass into a higher degree of oxydization.

Action of Atmospheric Air.—Atmospheric air produces various effects upon salts; those which contain much water of crystallization, and which have not much affinity for water, become dry, and fall into powder; they are said to *effloresce;* such are the *salts of soda*, &c. (See the table further on.)

Professor Faraday observed, that in many instances the efflorescence of salts is the result of superficial fracture, since several of the most efflorescent salts, such as sulphate of soda, the carbonate and phosphate of the same base, do not effloresce when perfectly entire and sheltered from external violence. The slightest scratch is, however, sufficient to induce efflorescence, which beginning at that point, soon extends to the whole crystal.

When they are anhydrous, and have much affinity for water, they absorb it, and deliquesce; they are then called *deliquescent salts*. All the salts which are very soluble deliquesce in a moist atmosphere.

Some salts undergo a chemical change by exposure to the air; this takes place when they contain an acid which is not saturated with oxygen; in such a case they absorb that of the air, and in doing so change their nature. Thus by exposure to the air, and by calcination, phosphites become phosphates; hyposulphites and sulphites, sulphates, &c.: sometimes the reverse is the case.

A LIST OF SALTS IN REFERENCE TO THE ACID, INDICATING THOSE WHICH ARE SOLUBLE AND THOSE WHICH ARE INSOLUBLE IN WATER.

Soluble in Water.

ACETATES, all except those in the opposite column.

ALUMINATES of potash.
„ soda.

ANTIMONIATES of potash.
„ soda.

ANTIMONITES.

ARSENIATES of potash.
„ soda.
„ ammonia.
„ lithia.
„ oxyde of vanadium.

ARSENITES of potash.
„ soda.
„ ammonia.

BENZOATES of ammonia.
„ potash.
„ soda.
„ lithia.
„ magnesia.
„ lime.
„ manganese.
„ cobalt.
„ copper.
„ iron.
„ bismuth.
„ silver (partly reduced).

BORATES of potash.
„ soda.
„ ammonia.
„ lithia.

Insoluble in Water.

ACETATES of mercury, iron } basic.
„ copper (tribasic).
„ molybdenum.
„ lead (hexabasic).
„ vanadium.
„ silver, sparingly.

ALUMINATES of magnesia.
„ iron.
„ zinc.

ANTIMONIATES, all except those in the opposite column.
„ baryta, lime, aluminium, manganese, zinc } are slightly soluble.

ANTIMONITE baryta, sparingly soluble.

ARSENIATES, all except those on the opposite side.
„ of baryta, strontia } are slightly soluble.

ARSENITES, all except those on the opposite side; that of baryta is slightly soluble.

BENZOATES of baryta, strontia, glucina, Yttria, zirconia, lead } are very sparingly soluble.

BORATES, all except those on the opposite side.
Those of barytes, strontia, lime, cadmium, silver } are sparingly soluble.
strontia is very sparingly soluble.
In fact, all the borates of earths and of metallic oxydes are nearly insoluble.

Soluble in water.

BOROFLUORIDES, all except those in the opposite column; 100 of water dissolve only $1\frac{1}{2}$ of borofluoride of potassium.

BROMATES, all except those in the other column.

BROMIDES, all except those in the opposite column; that *of lead* is difficultly, but entirely soluble; that *of bismuth* is decomposed.

CARBONATES of alkalies.

CHLORATES, all.

CHLORIDES, all except those in the other column.

CHROMATES of alkalies.
„ lithia.
„ lime.
„ magnesia.
„ chloride of potash is decomposed into $KO,2CrO_3+HCl$.

CITRATES of potash.
„ soda.
„ lithia.
„ ammonia.
„ glucina.
„ zirconia.
„ teroxyde of iron.
„ copper.
„ vanadium very slowly.
„ magnesia, alumina, protoxyde of manganese } acid salts.

CYANATES of potash.
„ ammonia.
„ baryta.

CYANIDES of alkaline acid and of earthy metals.
„ mercury.
„ platinum.
„ gold.
There is no cyanide of aluminium.
„ barium is only sparingly soluble.

Insoluble in water.

BOROFLUORIDES of copper, lead } decomposed.
„ yttria.
„ *strontia is unknown.*

BROMATES of silver, almost insoluble.
„ lead, slightly soluble.
„ baryta, slightly soluble.

BROMIDES of mercury.
„ silver.
„ platinum, sparingly soluble.
„ antimony, tellurium, bismuth } decomposed.

CARBONATES of earths and of metallic oxydes.

CHLORATES.

CHLORIDES of silver.
„ (sub.) of mercury.
„ lead, sparingly soluble.
„ bismuth, (proto.) of tin, antimony } decomposed by water into a soluble acid salt and an insoluble basic salt.

CHROMATES, all except those in the other column.

CITRATES, all except those in the other column.
„ those of copper, cadmium } are very sparingly soluble.
„ zinc, uranium, iron } sparingly soluble.
„ magnesia, alumina, proto. of manganese } neutral salts.
„ lead is decomposed.

CYANATES, all except those in the opposite column; that of lead is sparingly soluble.

CYANIDES, all except those in the opposite column.

Soluble in Water.

FERROCYANIDES of potassium.
„ sodium.
„ ammonium.
„ strontium.
„ calcium.
„ magnesium.

FERRICYANIDES of potassium.
„ sodium.
„ ammonium.
„ barium.
„ strontium.

FLUORIDES, all except those in the opposite column; those of lithium with difficulty; tin coagulates by boiling.
There is no fluoride of gold.

FORMIATES, all except those in the opposite column.

FULMINATES of potash.
„ soda.
„ magnesia.
„ alumina.
„ copper.

GALLATES of potash.
„ soda.
„ ammonia (sparingly).
„ manganese.
„ iron.
„ zinc.
„ cobalt.
„ nickel.

HYPOPHOSPHITES, all without exception.

HYPOSULPHATES, all.

HYPOSULPHITES, all except those in the opposite column.

IODATES, of soda.
„ strontia.
„ mercury.
„ potash.

Insoluble in Water.

FERROCYANIDES, all except those in the other column.
„ iron.
„ lead.
„ copper.
„ nickel.
„ cobalt.
„ manganese.
„ barium, very slightly soluble.
„ bismuth.
„ tin.

FERRICYANIDE of mercury is decomposed.

FLUORIDES of calcium.
„ magnesium.
„ yttrium.
„ thorinum.
„ cerium.
„ nickel.
„ strontium
„ iron
„ barium } sparingly soluble.
„ copper
„ cobalt
„ cadmium
„ lead } very sparingly soluble.
„ zinc

FORMIATES of thorina is decomposed.
„ cobalt
„ nickel
„ mercury } are sparingly soluble.
„ vanadium

FULMINATES, all except those in the opposite column.
Those of
cobalt
nickel } are sparingly soluble.
silver
cadmium, very sparingly soluble.

GALLATES, all except those in the opposite column.

HYPOPHOSPHITES.

HYPOSULPHATES.

HYPOSULPHITES of silver } sparingly soluble.
„ magnesia
„ baryta, very sparingly soluble.

IODATES, all except those in the opposite column.
Those of
lime
iron } are sparingly soluble.
zinc

Soluble in Water.

IODIDES, all except those in the opposite column.

LACTATES, all.

MALATES, all except those in the opposite column.

MANGANATES of soda.
„ potash (soon decomposed).

MECONATES.

MOLYBDATES of soda.
„ potash.
„ ammonia.
„ magnesia.
„ nickel.
„ vanadium.

NITRATES, all except those in the opposite column.

NITRITES, all.

OXALATES of potash.
„ soda.
„ lithia.
„ ammonia.
„ glucina.
„ peroxyde of iron.
„ molybdenum.
„ vanadium (slowly).
„ chromium.

PERCHLORATES, all except those in the opposite column.

PERMANGANATES of copper.
„ magnesia.
„ potash.
„ silver.
„ soda.
„ zinc.

PHOSPHATES of potash.
„ soda.
„ ammonia.
„ vanadium.
all the acid phosphates are soluble.

Insoluble in Water.

IODIDES of bismuth.
„ copper.
„ mercury.
„ platinum.
„ silver.
„ Those of lead
„ gold } sparingly soluble and
„ antimony } decomposed.
„ tin

LACTATES.

MALATES of barytes (basic).
„ lead, almost insoluble.
„ lime
„ zinc } are sparingly soluble.
„ silver
„ mercury, decomposed.

MANGANATES of potash (decomposed).
„ baryte.

MOLYBDATES, all except those on the opposite side.
Those of
copper
manganese } sparingly soluble.
„ lead, almost insoluble.

NITRATES of lead (basic).
„ bismuth } decomposed.
„ mercury

NITRITES.

OXALATES, all except those in the opposite column.
Those of
„ strontium
„ manganese } very sparingly soluble.
„ mercury
„ antimony } sparingly.
„ uranium
„ baryta.

PERCHLORATES of potash, only about 2 per cent.
„ ammonia.

PERMANGANATE of baryta.

PHOSPHATES, all except those in the opposite column; those of
„ barium, very sparingly soluble.
„ manganese
„ uranium } sparingly soluble.
„ molybdenum
„ bismuth, partly soluble.
„ magnesia, decomposed by boiling.

Soluble in Water.

Phosphites of potash.
„ soda.
„ ammonia.

Phosphuret—

Pyrotartrates of potash.
„ soda.
„ ammonia.

Seleniates of alumina.
„ copper.
„ iron.
„ magnesia.
„ potash.
„ silver.
„ soda.
„ zirconia.

Selenites of potash.
„ soda.
„ lithia.
„ ammonia.

Seleniurets of alkalies.

Silicates of alkalies with excess of base.

Silicofluorides of lithia, difficultly soluble.
„ alumina.
„ ammonia.
„ magnesia.
„ glucina.
„ zirconia.
„ manganese.
„ iron.
„ zinc.
„ cadmium.
„ lead.
„ tin.
„ silver.
„ vanadium.

Sulpharseniate of potash.
„ soda.
„ lithia.
„ ammonia.
„ baryta.
„ strontia.
„ lime.
„ magnesia.

Insoluble in Water.

Phosphites, all except those in the opposite column; those of
„ magnesia, lime, alumina, cobalt, nickel } sparingly soluble.
„ strontia, decomposed.

Phosphuret of aluminum, decomposed.
„ antimony.
„ barium, decomposed.
„ cadmium.

Pyrotartrates of mercury.
„ silver.
Those of
„ baryta, strontia, lime, zinc, cadmium } are sparingly soluble.

Seleniates of barytes.
„ calcium, sparingly soluble.
„ lead.
„ nickel.

Selenites, all except those in the opposite column.
Those of
„ magnesia, silver } very syaringly soluble.
„ lime, glucina, lead, mercury } sparingly soluble.

Seleniurets, all except those in the other column.

Silicates, all except those on the opposite side.

Silicofluorides of potash, soda, baryta } very sparingly soluble.
„ lime, decomposed.

Sulpharseniate of manganese is sparingly soluble.

Soluble in Water.

Sulpharsenites of potash.
„ soda.
„ lithia.
„ baryta.
„ lime.
„ magnesia.

Succinates of potash.
„ soda.
„ ammonia.
„ magnesia.
„ manganese.
„ zinc.
„ tin.
„ bismuth.
„ strontia (difficultly).
„ silver (slowly).

Sulphates, all except those in the other column, that of bismuth in decomposed.
There is no sulphate of gold.

Sulphites of alkalies.
„ glucina.
„ tin (protox).
„ chromium, but by boiling the excess of acid is disengaged and Cr_2O_3 is precipitated.

Sulphocarbonates of potash.
„ soda.
„ lithia.
„ ammonia.
„ magnesia.
„ cadmium.

Sulphocyanides, all except in the other column.
„ of potassium.
„ ammonium.
„ manganese.
„ iron.
„ barium.
„ copper.

Sulphurets of alkalies and of
„ earths.

Tannates of potash.
„ soda.
„ ammonia.

Tantalates of potash.
„ soda.

Insoluble in Water.

Sulpharsenites—

Succinates, all except those in the opposite column.
Those of
„ baryta, lime, alumina, glucina, thorina, cerium, iron, cobalt, nickel } sparingly soluble

Sulphates of baryta.
„ strontia.
„ palladium.
„ molybdenum.
„ lime, lead, mercury (suboxyde), cobalt (basic) } sparingly soluble.
„ mercury (peroxyde), antimony, bismuth } decomposed.

Sulphites, all except those in the opposite column.
Those of
„ strontia, copper } very sparingly soluble.
„ magnesia, zinc } sparingly soluble.

Sulphocarbonates, all except those on the other side; those of
„ baryta, strontia } sparingly soluble.

Sulphocyanides of calcium,
„ lead (basic).
„ mercury.
„ silver.

Sulphurets of metals, some are sparingly soluble.

Tannates of baryta.
„ strontia.
„ magnesia.
„ peroxyde of iron.
„ lead.

Tantalates of baryta.
„ lime.
„ alumina.

Soluble in Water.

TARTRATES, all except in the opposite column. The acid tartrates are sparingly soluble, except those of cobalt and nickel.

TELLURATES of potash.
„ soda.
„ ammonia.
„ lime.
„ magnesia.

TELLURITES of potash, difficultly.
„ soda.
„ ammonia.

Insoluble in Water.

TARTRATES of lead.
„ zinc.
„ bismuth.
Those of
„ baryta
„ strontia
„ yttria
„ lime
„ iron — sparingly soluble.
„ cadmium
„ tin
„ mercury
„ silver
„ lime — very sparingly soluble.
„ manganese.

TELLURATES of lead.
„ mercury
„ baryta — sparingly soluble.
„ strontia
„ silver, decomposed.

TELLURITES of mercury
„ silver.
„ lead, very sparingly soluble.
„ baryta — sparingly.
„ strontia

Soluble in Water.

TUNGSTATES of alkalies.
„ magnesia.
„ molybdenum.
„ vanadium.

VANADATES of potash, (difficultly.)
„ soda.
„ lithia.
„ lime.
„ magnesia.
„ zirconia.
„ peroxyde of iron.

VANADITES of alkalies.
„ glucina
„ nickel.
„ tin.

Insoluble in Water.

TUNGSTATES of baryta.
„ strontia.
„ lime.
„ alumina.
„ yttria.
„ thorina.
„ manganese.
„ iron.
„ zinc.
„ lead.
„ uranium.

VANADATES of baryta
„ strontia
„ yttria — sparingly soluble in water.
„ manganese
„ mercury

VANADITES of zinc.
„ uranium.
„ silver
„ alumina — sparingly soluble.

A LIST OF SALTS IN REFERENCE TO THE BASE, INDICATING THOSE WHICH ARE SOLUBLE, AND THOSE WHICH ARE INSOLUBLE IN WATER.

Soluble in Water.

ALUMINIUM—
„ acetate.
„ ammonio-chloride.
„ benzoate.
„ bromide.
„ carbonate.*
„ chlorate.
„ chloride.
„ citrate, acid salt.
„ fulminate.
„ hyposulphate.
„ hyposulphite.
„ lactate.
„ nitrate.
„ nitrite.
„ oxalate, acid salt.
„ phosphate, acid salt.
„ silicofluoride.
„ sulphate.
„ sulphite.
„ sulphocyanide.
„ tartrate.

AMMONIUM—
„ All with the single exception of the other column.

Insoluble in Water.

ALUMINIUM—
„ antimoniate, slightly soluble.
„ arseniate.
„ arsenite.
„ borate.
„ citrate, neutral.
„ oxalate, neutral.
„ phosphate, neutral.
„ phosphite, sparingly soluble.
„ phosphuret, decomposed by water.
„ silicate.
„ succinate, sparingly soluble.
„ sulphuret, decomposed.
„ tantalate.
„ tungstate.
„ vanadite.

AMMONIUM—
„ ammonio-chloride of platinum, very sparingly soluble.

Soluble in Water.

ANTIMONY—
„ acetate.
„ tartrate.

ARSENIC—
„ All the salts of arsenic, are either insoluble in, or are decomposed by water, as shown in the column on the opposite side.

BARIUM—
„ acetate.
„ borofluoride.
„ bromide.
„ chlorate.
„ chloride,

Insoluble in Water.

ANTIMONY—
„ arseniate.
„ arseniuret.
„ benzoate.
„ bromide, decomposed.
„ chloride, decomposed.
„ chromate.
„ iodide, decomposed.
„ oxalate, sparingly soluble.
„ phosphate.
„ phosphuret.
„ seleniuret.
„ sulphate, decomposed.
„ sulphite.
„ sulphuret.
„ tannate.

ARSENIC—
„ bromide
„ chloride
„ fluoride
„ iodide — decomposed.
„ phosphuret
„ seleniuret.
„ sulphurets, &c., sparingly soluble.

BARIUM—
„ antimoniate, sparingly soluble.
„ antimonite, sparingly soluble.
„ arseniate, sparing soluble.
„ benzoate, very sparingly soluble
„ borate, sparingly soluble.

* The precipitate produced by the carbonates of alkalies in solutions of salts of aluminium consists entirely of hydrate of alumium mixed with the carbonate of alkali employed. Yet water containing an excess of carbonic acid dissolves this hydrate; by exposure to the air, however, the combination is destroyed, and hydrate of alumina is reprecipitated. Carbonate of alumina, therefore, does not exist except under the circumstances just mentioned.

Soluble in Water.

Barium — citrate.
„ cyanate.
„ ferrocyanide.
„ ferricyanide.
„ hyposulphate.
„ iodide.
„ lactate.
„ nitrate.
„ sulpharseniate.
„ sulpharsenite.
„ sulphocyanide.
„ sulphuret.

Bismuth—
„ acetate.
„ benzoate.
„ chlorate.
„ fluoride.
„ hyposulphate.

Cadmium—
„ acetate.
„ bromide.
„ chloride.
„ hyposulphate.
„ iodide.
„ nitrate.
„ silicofluoride.
„ sulphate.

Insoluble in Water.

Barium — carbonate.
„ chromate.
„ cyanide, sparingly soluble.
„ ferrocyanide, very sparingly soluble.
„ fluoride, sparingly soluble.
„ hyposulphite.
„ iodate.
„ malate (basic).
„ manganate.
„ molybdate.
„ oxalate.
„ permanganate.
„ phosphate, very sparingly soluble.
„ phosphite, sparingly soluble.
„ phosphuret, decomposed.
„ pyrotartrate, sparingly soluble.
„ seleniate.
„ selenite.
„ silicate.
„ silicofluoride, very sparingly soluble.
„ succinate.
„ sulphate, sulphite.
„ sulphocarbonate, sparingly soluble.
„ tannate.
„ tantalate.
„ tartrate.
„ tellurate, sparingly soluble.
„ tellurite, sparingly soluble.
„ tungstate.
„ vanadate, sparingly soluble.

Bismuth—
„ arseniate.
„ borate.
„ bromide, decomposed.
„ carbonate.
„ chloride, decomposed.
„ chromate.
„ citrate.
„ ferrocyanide.
„ iodate.
„ iodide.
„ nitrate, decomposed.
„ oxalate.
„ phosphate, decomposed.
„ seleniuret.
„ sulphate, decomposed.
„ sulphuret.
„ tartrate.

Cadmium—
„ borate, sparingly soluble.
„ carbonate.
„ chromate.
„ citrate, sparingly soluble.
„ fluoride.
„ fulminate.
„ molybdate.
„ oxalate.
„ phosphate.
„ phosphuret.
„ pyrotartrate, sparingly soluble.
„ sulphocarbonate.
„ sulphuret.
„ tartrate.

Soluble in Water.

Calcium—
„ aluminate.
„ benzoate.
„ bromide.
„ chlorate.
„ chloride.
„ chromate.
„ ferrocyanide.
„ hypophosphite.
„ hyposulphate.
„ hyposulphite.
„ iodide.
„ nitrate.
„ perchlorate.
„ seleniuret.
„ sulpharseniate.
„ sulpharsenite.
„ sulphuret.
„ tellurate.
„ vanadate

Cerium—
„ acetate.
„ chloride
„ hyposulphate.
„ sulphate.

Chromium—
„ bromide.
„ chloride.
„ chromate.
„ fluoride.
„ iodide.
„ nitrate.
„ oxalate.
„ phosphate.
„ sulphate.
„ sulphite.*

Cobalt—
„ acetate.
„ benzoate.
„ bromide.
„ chloride.
„ gallate.
„ hyposulphate.
„ iodide.
„ nitrate.
„ sulphate.

* Sulphite of chromium is soluble in water but by boiling, the excess of SO_2 is disengaged and C_2O_3 is precipitated.

Insoluble in Water.

Calcium—
„ antimoniate, sparingly soluble.
„ antimonite, difficultly.
„ arseniate.
„ arsenite.
„ borate, sparingly soluble.
„ borofluoride.
„ carbonate.
„ citrate.
„ cyanide.
„ fluoride.
„ iodate, sparingly soluble.
„ malate, sparingly soluble.
„ meconate.
„ molybdate.
„ oxalate, sparingly soluble.
„ phosphate.
„ phosphite, sparingly soluble.
„ phosphuret, decomposed.
„ pyrotartrate, sparingly soluble.
„ seleniate, sparingly soluble.
„ selenite, sparingly soluble.
„ silicate.
„ silicofluoride.
„ succinate, sparingly soluble.
„ sulphate, sparingly soluble.
„ sulphocyanide.
„ tannate.
„ tartrate, very sparingly soluble.
„ tungstate.
„ vanadate.

Cerium—
„ carbonate.
„ fluoride.
„ oxalate.
„ phosphate.
„ succinate, sparingly soluble.
„ sulphuret.
„ tartrate.

Chromium—
„ arseniate.
„ carbonate.*
„ molybdate.
„ phosphuret.
„ sulphuret.

Cobalt—
„ antimoniate.
„ antimonite.
„ arseniate.
„ arseniuret.
„ borate.
„ carbonate.
„ chromate.
„ citrate.

* When a carbonate of alkali is added to a solution of a salt of chromium, a greyish green precipitate falls, which is not a pure carbonate, but a mixture of a subcarbonate and of oxyde of chromium.

Soluble in Water.

Cobalt—
- „ sulphocyanide.
- „ tartrate.

Copper—
- „ acetate.*
- „ benzoate.
- „ chlorate.
- „ chloride.
- „ fulminate.
- „ hyposulphate.
- „ hyposulphite.
- „ nitrate.
- „ permanganate.
- „ seleniate.
- „ sulphate.
- „ sulphocyanide.
- „ tartrate.

Glucinium—
- „ chloride.
- „ citrate.
- „ oxalate.
- „ silicofluoride.
- „ sulphate.
- „ vanadite.

Gold—
- „ bromide.
- „ chloride.

Iridium—
- „ chloride.
- „ sulphate.

Insoluble in Water.

Cobalt—
- „ ferrocyanide.
- „ fluoride, sparingly soluble.
- „ formiate.
- „ fulminate, sparingly soluble.
- „ molybdate.
- „ oxalate.
- „ phosphate.
- „ phosphite, sparingly soluble.
- „ phosphuret.
- „ selenite.
- „ seleniuret.
- „ succinate, sparingly soluble.
- „ sulphate, sparingly soluble (basic).
- „ sulphuret.

Copper—
- „ acetate.*
- „ antimoniate.
- „ antimonite.
- „ arseniate.
- „ arsenite.
- „ borate.
- „ borofluoride.
- „ carbonate.
- „ carburet.
- „ chromate.
- „ citrate, sparingly soluble.
- „ cyanide.
- „ ferrocyanide.
- „ fluoride, sparingly soluble.
- „ iodate.
- „ iodide.
- „ oxalate.
- „ phosphate.
- „ phosphuret.
- „ seleniuret.
- „ silicate.
- „ succinate.
- „ sulphite, sparingly solub e.
- „ sulphuret.

Glucinium—
- „ carbonate.
- „ phosphate.
- „ phosphuret.
- „ selenite, sparingly soluble.
- „ seleniuret, sparingly soluble.
- „ succinate, sparingly soluble.
- „ sulpuhret, sparingly soluble.

Gold—
- „ cyanide.
- „ iodide, sparingly soluble.
- „ sulphocyanide.
- „ sulphuret.
- „ phosphuret.

Iridium—
- „ sulphuret.

* The tribasic acetate of Copper $3CuO,2\overline{A}$ is only sparingly soluble in cold water, and is decomposed into a subacetate with large excess of base and of a brown colour by boiling.

Soluble in Water.

Iron—
- „ acetate.
- „ benzoate.
- „ bromide.
- „ chlorate.
- „ chloride.
- „ citrate.
- „ gallate.
- „ hyposulphate.
- „ hyposulphite.
- „ iodide.
- „ nitrate.
- „ seleniate.
- „ silicofluoride.
- „ sulphate.
- „ sulphocyanide.

Lead—
- „ acetate.*
- „ bromate, difficultly.
- „ bromide, difficultly
- „ chlorate.
- „ ferrocyanide.
- „ hyposulphate
- „ hyposulphite.
- „ nitrate.
- „ nitrite.
- „ silicofluoride.

* The hexabasic acetate of lead $6PbO,\overline{A}$, which is formed by adding a large excess of NH_3 to a solution of the neutral acetate of lead, is insoluble in cold and scarcely soluble in hot water.

Insoluble in Water.

Iron—
- „ antimoniate.
- „ arseniate.
- „ borate.
- „ carbonate.
- „ carburet.
- „ chromate.
- „ cyanide.
- „ ferrocyanide.
- „ ferricyanide.
- „ fluoride, sparingly soluble.
- „ iodate, sparingly soluble.
- „ Molybdate.
- „ oxalate.
- „ phosphate.
- „ phosphuret.
- „ succinate, sparingly soluble.
- „ sulphite.
- „ sulphuret.
- „ tannate.
- „ tartrate, sparingly soluble.
- „ tungstate.

Lead—
- „ antimoniate.
- „ antimonite.
- „ arseniate.
- „ arseniuret.
- „ benzoate, very sparingly soluble.
- „ borate.
- „ carbonate.
- „ carburet.
- „ chloride, sparingly soluble.
- „ chromate.
- „ citrate, decomposed.
- „ cyanate.
- „ cyanide.
- „ fluoride, very sparingly soluble.
- „ gallate.
- „ iodate.
- „ iodide, sparingly soluble.
- „ malate.
- „ molybdate.
- „ nitrate, basic.
- „ oxalate.
- „ phosphate.
- „ phosphite.
- „ phosphuret.
- „ seleniate.
- „ selenite.
- „ silicate·
- „ succinaate.
- „ sulphate, sparingly soluble.
- „ sulphite.
- „ sulphocyanide, basic.
- „ sulphuret.
- „ tannate.
- „ tartrate.
- „ tellurate.
- „ tungstate.

Soluble in Water.

LITHIUM—
- „ acetate.
- „ arseniate.
- „ benzoate.
- „ borate.
- „ chloride.
- „ chromate.
- „ citrate.
- „ fluoride, difficultly.
- „ iodide.
- „ nitrate.
- „ oxalate.
- „ selenite.
- „ sulphate.
- „ sulphuret.
- „ tartrate.
- „ vanadate.

MAGNESIUM—
- „ acetate.
- „ benzoate.
- „ bromide.
- „ chlorate.
- „ chloride.
- „ chromate.
- „ citrate (acid).
- „ cyanide.
- „ ferrocyanide.
- „ fulminate.
- „ hypophosphite.
- „ hyposulphate.
- „ iodide.
- „ malate.
- „ molybdate.
- „ nitrate
- „ permanganate.
- „ phosphuret.
- „ seleniate.
- „ silicofluoride.
- „ succinate.
- „ sulphate.
- „ sulphuret.
- „ tartrate.
- „ tungstate.
- „ vanadate.

MANGANESE—
- „ acetate.
- „ antimonite.
- „ benzoate.
- „ chlorate.
- „ chloride.
- „ citrate (acid).
- „ fluoride.
- „ gallate.
- „ hyposulphite.
- „ iodide.
- „ nitrate.
- „ sulphate.
- „ sulphocyanide.
- „ succinate.
- „ tartrate.

Insoluble in Water.

LITHIUM—
- „ carbonate, very sparingly soluble.
- „ phosphate.

MAGNESIUM—
- „ alumınate.
- „ antimoniate.
- „ arseniate.
- „ borate.
- „ carbonate.
- „ citrate, neutral.
- „ fluoride.
- „ hyposulphite.
- „ iodate.
- „ oxalate.
- „ phosphate.
- „ phosphite, sparingly soluble.
- „ selenite, very sparingly soluble.
- „ silicate.
- „ sulphite.

MANGANESE—
- „ aluminate.
- „ antimoniate, sparingly soluble.
- „ arseniate.
- „ borate.
- „ carbonate.
- „ carburet.
- „ chromate.
- „ citrate, neutral.
- „ cyanide.
- „ ferrocyanide.
- „ molybdate, spparingly soluble.
- „ oxalate.
- „ phosphate.
- „ phosphuret.
- „ silicate.
- „ sulpharseniate, sparingly soluble.
- „ sulphite.

Soluble in Water.

MERCURY—
- „ acetate, sparingly soluble.
- „ ammonio-chloride.
- „ benzoate.
- „ bromide, per.
- „ chlorate, per.
- „ chloride, per.
- „ cyanide.
- „ fluoride, decomposed.
- „ hyposulphite.
- „ iodate.
- „ malate, decomposed.
- „ nitrate, per.
- „ nitrate, sub.
- „ sulphate, per. decomp.

MOLYBDENUM—
- „ ammonio-chloride.
- „ bromide.
- „ chloride.
- „ fluoride.
- „ iodide.
- „ oxalate.
- „ tungstate.

NICKEL—
- „ acetate.
- „ ammonio-chloride.
- „ benzoate.
- „ bromide.
- „ chloride.
- „ citrate.
- „ gallate.
- „ iodide.
- „ molybdate.
- „ nitrate.
- „ vanadite.

Insoluble in Water.

MANGANESE—
- „ sulphuret.
- „ tungstate.
- „ vanadate, sparingly soluble.

MERCURY—
- „ arseniate.
- „ borate.
- „ bromide, sub.
- „ chlorate, sub., sparingly soluble.
- „ chloride, sub.
- „ chromate.
- „ citrate, neutral.
- „ ferrocyanide, decomposed
- „ fluoride, decomposed.
- „ formiate.
- „ fulminate.
- „ iodide.
- „ malate, decomposed.
- „ molybdate.
- „ nitrate, sub., decomposed by large quantity of water.
- „ oxalate, very sparingly soluble.
- „ phosphate.
- „ phosphuret.
- „ pyrotartrate, sparingly soluble.
- „ seleniate, sparingly soluble.
- „ seleniuret.
- „ succinate.
- „ sulphate, sub.
- „ sulphate, per., decomposed.
- „ sulphite.
- „ sulphocyanide.
- „ sulphuret
- „ tartrate.
- „ tellurate.
- „ tellurite.

MOLYBDENUM—
- „ acetate.
- „ carbonat
- „ chromate.
- „ phosphate sparingly soluble
- „ sulphuret.
- „ sulphate.

NICKEL—
- „ antimoniate.
- „ arseniate.
- „ arseniuret.
- „ borate.
- „ chromate.
- „ cyanide.
- „ ferrocyanide.
- „ fluoride.
- „ formiate.
- „ fulminate, sparingly soluble.
- „ oxalate.
- „ phosphate, sparingly soluble.
- „ phosphite, sparingly soluble.
- „ phosphuret.
- „ seleniate.
- „ selenite.

Soluble in Water.

PALLADIUM—
„ chloride.
„ nitrate.

PLATINUM—
„ chloride.
„ cyanide.
„ nitrate.
sulphate.

POTASSIUM—
„ acetate.
„ aluminate.
„ antimoniate.
„ antimonite.
„ arseniate.
„ arsenite.
„ benzoate.
„ borate.
„ borofluoride.
„ bromate.
„ bromide.
„ carbonate.
„ chlorate.
„ chloride.
„ chromate.
„ citrate.
„ cyanate.
„ cyanide.
„ ferrocyanide.
„ ferricyanide.
„ fluoride
„ formiate.
„ fulminate.
„ hypophosphite.
„ hyposulphate.
„ hyposulphite.
„ iodate.
„ iodide.
„ lactate.
„ malate.
„ manganate decomposed.
„ meconate.
„ molybdate.
„ nitrate.
„ oxalate.
„ permanganate.
„ phosphate.
„ phosphite.
„ pyrotartrate.
„ seleniate.
„ selenite.
„ silicate (basic).
„ succinate.
„ sulpharseniate.

Insoluble in Water.

NICKEL—
„ succinate, sparingly soluble.
„ sulphuret.

PALLADIUM—
„ carburet.
„ cyanide.
„ seleniuret.
„ sulphate.
„ sulphuret.

PLATINUM—
„ ammonio-chloride, very sparingly soluble
„ bromide.
„ iodide.
„ phoshuret.
„ seleniuret.
„ sulphocyanide.
„ sulphuret.

POTASSIUM—
„ perchlorate, very sparingly soluble.
„ phosphuret decomposed.
„ silicate.
„ silicofluoride, very sparingly soluble.
„ tartrate, sparingly soluble.

Soluble in Water.

POTASSIUM—
„ sulpharsenite.
„ sulphate.
„ sulphite.
„ sulphocarbonate.
„ sulphocyanide.
„ sulphuret.
„ tannate.
„ tantalate.
„ tartrate.
„ tellurate.
„ tellurite.
„ titaniate.
„ tungstate.
„ vanadate.
„ vanadite.

RHODIUM—
„ chloride.
„ nitrate.
„ sulphate.

SILVER—
„ acetate, sparingly soluble.
„ benzoate, partly reduced.
„ borate.
„ chlorate.
„ fluoride.
„ hypophosphite.
„ hyposulphate.
„ nitrate.
„ nitrite.
„ oxalate.
„ permanganate.
„ seleniate.
„ silicofluoride.
„ succinate, slowly.
„ sulphate, slowly.

SODIUM—
„ acetate.
„ aluminate.
„ antimoniate.
„ arseniate.
„ arsenite.
„ benzoate.
„ borate.
„ borofluoride.

Insoluble in Water.

RHODIUM—
„ sulphuret.

SILVER—
„ antimoniate.
„ arseniate.
„ bromide.
„ carbonate.
„ chloride.
„ chromate.
„ citrate.
„ cyanate.
„ cyanide.
„ ferrocyanide.
„ fulminate, sparingly soluble.
„ hyposulphite.
„ iodate.
„ iodide.
„ malate, sparingly soluble.
„ manganate.
„ meconate.
„ molybdate.
„ phosphate.
„ phosphite.
„ phosphuret.
„ pyrotartrate.
„ selenite, very sparingly soluble.
„ seleniuret.
„ silicate.
„ sulphite.
„ sulphocyanide.
„ sulphuret.
„ tartrate.
„ tellurate, decomposed.
„ tungstate.
„ vanadite.

SODIUM—
„ silicofluoride, very sparingly soluble.
„ meta-antimoniate.
„ SILICATES (acid).

Soluble in Water.

Sodium—
- „ bromate.
- „ bromide.
- „ carbonate.
- „ chlorate.
- „ chloride.
- „ chromate.
- „ citrate.
- „ cyanide.
- „ ferrocyanide.
- „ ferricyanide.
- „ fluoride.
- „ formiate.
- „ fulminate.
- „ gallate.
- „ hypochlorite.
- „ hypophosphite.
- „ hyposulphate.
- „ hyposulphite.
- „ iodate.
- „ iodide.
- „ lactate.
- „ malate.
- „ manganate.
- „ meconate.
- „ molybdate.
- „ nitrate.
- „ oxalate.
- „ perchlorate.
- „ permanganate.
- „ phosphate.
- „ phosphite.
- „ pyrotartrate.
- „ seleniate.
- „ selenite.
- „ silicate (basic).
- „ succinate.
- „ sulpharseniate.
- „ sulpharsenite.
- „ sulphate.
- „ sulphite.
- „ sulphocarbonate.
- „ sulphocyanide.
- „ sulphuret.
- „ tannate.
- „ tantalate.
- „ tartrate.
- „ tellurate.
- „ tungstate.
- „ vanadate.
- „ vanadite.

Strontium—
- „ acetate.
- „ arseniate, slightly.
- „ bromide.
- „ chlorate.
- „ chloride.
- „ cyanide.
- „ ferrocyanide.
- „ ferricyanide.
- „ hypophosphite.
- „ hyposulphate.
- „ hyposulphite.

Insoluble in Water.

Strontium—
- „ benzoate, very sparingly soluble.
- „ borate, very sparingly soluble.
- „ carbonate.
- „ chromate
- „ citrate.
- „ fluoride, sparingly soluble.
- „ molybdate.
- „ oxalate, very sparingly soluble.
- „ phosphate.
- „ phosphite, decomposed.
- „ phosphuret, decomposed.

Soluble in Water.

Strontium—
- „ iodate.
- „ iodide.
- „ nitrate.
- „ succinate, difficultly.
- „ sulpharseniate.
- „ sulphocyanide.
- „ sulphuret.

Tellurium—
- „ bromide, decomposed.
- „ chloride.
- „ iodide.

Tin—
- „ acetate.
- „ benzoate.
- „ chloride, decomposed.
- „ fluoride, coagulates by boiling.
- „ hyposulphite.
- „ nitrate.
- „ silicofluoride.
- „ succinate.
- „ sulphate.
- „ sulphite.
- „ vanadite.

Titanium—
- „ chloride.
- „ tartrate

Uranium—
- „ acetate.
- „ benzoate.
- „ bromide.
- „ chloride.
- „ nitrate.
- „ sulphate.
- „ tartrate.

Vanadium—
- „ arseniate.
- „ citrate.
- „ molybdate.
- „ phosphate.
- „ silicofluoride.
- „ chloride.
- „ nitrate.
- „ tungstate.

Yttrium—
- „ bromide.

Insoluble in Water.

Strontium—
- „ pyrotartrate, sparingly soluble.
- „ selenite.
- „ sulphate.
- „ sulphite.
- „ tannate.
- „ tartrate.
- „ tellurate.
- „ tungstate.
- „ vanadate.

Tellurium—
- „ sulphuret.

Tin—
- „ arseniate.
- „ arseniuret.
- „ borate.
- „ carbonate.
- „ chloride, decomposed.
- „ chromate.
- „ citrate.
- „ ferrocyanide.
- „ iodate.
- „ molybdate.
- „ oxalate.
- „ phosphate.
- „ phosphite.
- „ phosphuret.
- „ sulphuret.
- „ tartrate.

Titanium—
- „ sulphuret.
- „ phosphuret.
- „ phosphate.

Uranium—
- „ arseniate.
- „ chromate.
- „ citrate, sparingly soluble.
- „ cyanide.
- „ ferrocyanide.
- „ molybdate.
- „ oxalate, very sparingly soluble.
- „ phosphate, sparingly soluble.
- „ phosphuret.
- „ sulphuret.
- „ tungstate.
- „ vanadite.

Vanadium—
- „ acetate.
- „ formiate.
- „ oxalate, very sparingly soluble.

Yttrium—
- „ benzoate, very sparingly soluble.

Soluble in Water.

Yttrium—
- „ chloride.
- „ iodide.
- „ nitrate.
- „ sulphate, slowly.

Zinc—
- „ acetate
- „ benzoate.
- „ bromide.
- „ chlorate.
- „ chloride.
- „ gallate.
- „ hyposulphate.
- „ hyposulphite.
- „ iodide.
- „ nitrate.

Insoluble in Water.

Yttrium—
- „ borofluoride.
- „ carbonate.
- „ fluoride.
- „ phosphate.
- „ phosphuret, decomposed.
- „ seleniuret.
- „ sulphuret.
- „ tartrate, sparingly soluble.
- „ tungstate.
- „ vanadate.

Zinc—
- „ aluminate
- „ antimoniate.
- „ arseniuret.
- „ borate.
- „ carbonate.
- „ chromate.
- „ citrate, sparingly soluble.
- „ cyanide.
- „ ferrocyanide.
- „ fluoride, very sparingly soluble.

Soluble in Water.

Zinc—
- „ permanganate.
- „ succinate.
- „ sulphate.
- „ sulphite.

Zirconium—
- „ chloride.
- „ citrate.
- „ fluoride.
- „ nitrate.
- „ seleniate.
- „ silicofluoride.
- „ sulphate.
- „ sulphuret.
- „ vanadate.

Insoluble in Water.

Zinc—
- „ iodate.
- „ malate.
- „ molybdate.
- „ oxalate.
- „ phosphate.
- „ pyrotartrate.
- „ silicate.
- „ sulphuret.
- „ tartrate.
- „ tungstate.
- „ vanadite.

Zirconium—
- „ Benzoate.
- „ Carbonate.
- „ Phosphate.
- „ Silicate.

A TABLE

OF THE ACTION OF THE ATMOSPHERE ON DIFFERENT SALTS.

Name of Salts.	Form.	Action of the Air.	
Chloride of Aluminium Al_2Cl_3	Crystals, semi-translucent	Deliquescent	
Bromide of Aluminium Al_2Br_3	Fine and short needles	Deliquescent	
Sulphate of Alumina and Potash $KO,SO_3+Al_2O_3,3SO_3$	Opaque cubes, or octahedrons		Slightly efflorescent.
Sulphate of Alumina and Soda $NaO,SO_3+Al_2O_3,3SO_3$	Ditto		Slightly efflorescent.
Sulphate of Alumina and Ammonia $NH_4O,SO_3+Al_2O_3,3SO_3$	Ditto		Slightly efflorescent.
Perchlorate of Alumina Al_2O_3,ClO_7	Crystals	Deliquescent.	
Chlorate of Alumina Al_2O_3,ClO_5	Crystals	Deliquescent.	
Oxalate of Alumina $Al_2O_3,\overline{O}$	Cannot crystallize	Deliquescent.	
Borate of Alumina Al_2O_3,BO_3		Deliquescent.	
Formiate of Alumina $Al_2O_3,\overline{Fo}O_3$	Gummy mass	Deliquescent.	

Name of Salts.	Form.	Action of the Air.	
Chlorate of Ammonia NH_4O,ClO_5			
Hydrofluate of Ammonia $NH_4Fl+HFl$	Granular and crystalline	Deliquescent.	
Sulphate of Ammonia NH_4O,SO_3	Flat prisms		Efflorescent by a gentle heat.
Bisulphate of Ammonia $NH_4O,2SO_3$	Crystals	Absorbs moisture.	
Neutral phosphate of Ammonia $(NH_4O)^2,HO,PhO_5$	Four-sided prisms		Efflorescent.
Ammonia-phosphate of Soda $NaO,HO,NH_4O,PhO_5,8HO$	Crystals		Efflorescent.
Phosphite of Ammonia $(2NH_4O),PhO_3$	Crystals	Deliquescent.	
Neutral bromate of Ammonia NH_4O,BO_3+BO_3,HO	Rhomboidal octahedra		Efflorescent.
Acetate of Ammonia $NH_4O,\overline{A}$	Long needles	Deliquescent.	
Tartrate of Ammonia $NH_4O,HO,\overline{T}$	Prismatic crystals		Efflorescent.

Name of Salts.	Form.	Action of the Air.	
Arseniate of Ammonia NH_4O,AsO_5	Prismatic, oblique crystals with rhomboidal base		Efflorescent.
Chloride of Antimony Sb_2Cl_3	Crystalline mass	Deliquescent.	
Sulphate of Antimony Sb_2O_3,SO_3	Crystalline needles	Deliquescent.	
Acid Tartrate of Antimony $Sb_2O_3,HO,\overline{T}_2,5HO$	Four-sided prisms	Deliquescent.	
Hyposulphate of Baryta BaO,S_2O_5	Four-sided prisms		Efflorescent.
Perchlorate of Baryta BaO,ClO_7	Long prisms	Deliquescent.	
Sulphate of Bismuth BiO,SO_3	Needles	Deliquescent.	
Chloride of Cadmium Cd,Cl	Rectangular, four-sided prisms		Efflorescent.
Silicofluoride of Cadmium $(3CdF)+2SiFl_3$	Long, colourless prisms		Efflorescent.
Hyposulphate of Cadmium CdO,S_2O_5	Saline mass	Deliquescent.	
Chloride of Calcium $CaCl$	Mass	Deliquescent.	
Sulphite of Lime CaO,SO_2	Pulverulent or hexagonal needles		Effloresces slowly, and becomes sulphate.
Hyposulphite of Lime CaO,S_2O_2	Large transparent hexagonal prisms		Efflorescent.
Nitrate of Lime CaO,NO_5	Long hexagonal prisms	Deliquescent.	
Acid Phosphate of Lime $CaO(HO)^2,PhO_5$	Small tables, or spangles	Deliquescent.	
Chlorate of Lime CaO,ClO_5	Crystallizes with difficulty	Deliquescent.	
Hypochlorite of Lime CaO,ClO	Mass	Deliquescent.	
Sulphocyanide of Cobalt $Co+CyS$	Prisms of a blue colour	Deliquescent.	
Sulphate of Cobalt CoO,SO_3	Red crystals		Efflorescent.
Nitrate of Cobalt CoO,NO_5	Small red crystals	Deliquescent.	
Hyposulphate of Cobalt CoO,S_2O_5	Large crystals, regular octahedrons		Efflorescent.

Name of Salts.	Form.	Action of the Air.	
Sulphate of protoxyde of Copper $CuO,SO_3,5HO$	Oblique parallelopiped crystals		Very slightly efflorescent.
Hyposulphate of Copper CuO,S_2O_5	Small prisms		Slightly efflorescent
Perchlorate of Copper CuO,ClO_7	Voluminous crystals	Deliquescent.	
Chlorate of Copper CuO,ClO_5	Green crystals	Deliquescent.	
Nitrate of Glucina Gl_2O_3,NO_5	Crystallizes with difficulty	Deliquescent.	
Perchloride of Gold $AuCl_3$	Pale yellow needles	Deliquescent in moist air.	
Potash-chloride of Gold $KCl+AuCl_3+5HO$	Striated prisms, or hexagonal tables		Efflorescent.
Bromide of Gold $AuBr_3$	Tables of a red colour		Efflorescent.
Perchloride of Iron Fe_2Cl_3	Fine red crystals	Deliquescent.	
Ferrocyanide of Sodium $(2NaCfy)12HO$	Four-sided prisms, with diedral summits, yellow		Efflorescent.
Ferrocyanide of Barium $2BaCfy$	Yellow rhomboidal prisms		Efflorescent.
Ferrocyanuret of Calcium $2CaCfy$	Pale yellow crystals, oblique, quadrilateral prisms		Efflorescent.
Ferrocyanuret of Magnesium $2MgCfy$	Small crystals	Deliquescent.	
Oxalate of protoxyde of Iron $FeO,\overline{O}$	Green prisms		Efflorescent.
Sulphate of peroxyde of Iron Fe_2O_3,SO_3	Pale yellow mass	Deliquescent.	
Nitrate of peroxyde of Iron Fe_2O_3,NO_5	Rectangular prisms	Deliquescent.	
Perchlorate of Lead PbO,ClO_7	Prismatic needles	Deliquescent.	
Chloride of Lithium $LiCl$	Cubes	Deliquescent.	
Nitrate of Lithia LiO,NO_5	Crystals	Deliquescent.	
Citrate of Lithia $LiO,\overline{C}$	Amorphous, transparent mass		Softens in the air.
Chloride of Magnesium $MgCl$	Needles very difficult to crystallize		Very deliquescent.
Chloride of Magnesium and of Potassium $KCl+2MgCl+12HO$	Octahedra	Deliquescent.	

Name of Salts.	Form.	Action of the Air.	
Chromate of chloride of Magnesium . . $MgCl+2CrO_3$ . .	. . . . .	Deliquescent.	
Bromide of Magnesium . MgBr	. . . . .	Deliquescent.	
Iodide of Magnesium . MgI	Crystallizes with difficulty .	Deliquescent.	
Sulphate of Magnesia . MgO,SO_3 . . .	Four-sided rectangular prisms	. . . .	Efflorescent.
Sulphite of Magnesia . MgO,SO_2 . . .	Transparent crystals . .	. . . .	Efflorescent.
Nitrate of Magnesia . MgO,NO_5 . . .	Crystals	Deliquescent.	
Nitrate of Ammonia and Magnesia . . . NH_4O,NO_5+MgO,NO_5	Crystals	Slowly deliquescent.	
Phosphate of Magnesia . $(MgO)^2,HO,PhO_5$.	Hexagonal needles . .	. . . .	Slowly efflorescent.
Perchlorate of Magnesia . MgO,ClO_7 . . .	Long needles . . .	Deliquescent.	
Chlorate of Magnesia . MgO,ClO_5 . . .	Crystals	Deliquescent.	
Acetate of Magnesia . $MgO,\overline{A}$ . . .	Gummy mass . . .	Deliquescent.	
Citrate of Magnesia . $MgO,\overline{C}$ . . .	. . . . .	Deliquescent.	
Succinate of Magnesia . $MgO,\overline{S}$ . . .	White gummy mass . .	. . . .	Efflorescent.
Seleniate of Magnesia . MgO,SeO_3 . . .	Four-sided rectangular prisms	. . . .	Efflorescent.
Bromide of Nickel . . NiBr	Needles of a dirty white colour	Deliquescent.	
Chloride of Osmium . . OsCl	Pulverulent . . .	Deliquescent.	
Soda-chloride of Palladium $NaCl+PdCl$ . .	Crystals	Deliquescent.	
Potassio-cyanide of Platinum . . . $KCy+PtCy+3HO$.	Crystals	. . . .	Efflorescent.
Cyanide of Potassium . KCy	Octahedrons . . .	Deliquescent.	
Bisulphate of Potash . $KO,2SO_3,HO$ . .	Prismatic crystals . .	. . . .	Slightly efflorescent.

Name of Salts.	Form.	Action of the Air.	
Sulphite of Potash . . KO,SO_2 . . .	Needles or flakes . .	. . . .	Efflorescent.
Carbonate of Potash . KO,CO_2 . . .	Rhomboidal tables . .	Deliquescent.	
Acetate of Potash . . $KO,\overline{A}$ . . .	Spangles	Deliquescent.	
Neutral Tartrate of Potash $(2KO),\overline{T}$ . . .	Crystallizes with difficulty .	Deliquescent.	
Succinate of Potash . . $KO,\overline{S}$ . . .	Crystals	Deliquescent.	
Formiate of Potash . . $KO,\overline{F}$ . . .	Spangles	Slightly deliquescent.	
Seleniate of Potash . . KO,SeO_3 . . .	Amorphous mass . .	Slightly deliquescent.	
Biselenite of Potash . $KO+2SeO_2$ . .	Feathery crystals . .	Deliquescent.	
Quadriselenite of Potash . $KO+4SeO_2$ . . .	Uncrystallizable . .	Deliquescent.	
Neutral arseniate of Potash KO,AsO_5 . . .	Saline mass . . .	Deliquescent.	
Basic arseniate of Potash $(3KO),AsO_5$. . .	Fine acicular crystals . .	Deliquescent.	
Chromate of Potash . . KO,CrO_3 . . .	Rhomboidal prisms . Crystals . . .	. . . .	Efflorescent.
Tungstate of Potash . KO,WO_3 . . .	Small crystals . . .	Deliquescent.	
Sulphate of Rhodium . R_2O_3,SO_3 . . .	Uncrystallizable mass . .	Very deliquescent.	
Nitrate of Rhodium . . R_2O_3,NO_5 . . .	Saline mass . . .	Deliquescent.	
Silici-fluoride of Silver . $(3AgFl)+2SiFl$ . .	White granular crystals .	Very deliquescent.	
Percholrate of Silver . AgO,ClO_7 . . .	White powder . . .	Very deliquescent.	
Iodide of Sodium . . NaI	Hexagonal tables . .	Deliquescent.	
Sulphate of Soda . . $NaO,SO_3,10HO$ . .	Large four-sided prisms .	. . . .	Efflorescent.
Nitrate of Soda . . NaO,NO_5 . . .	Crystallizes with difficulty .	Deliquescent.	
Bromate of Soda . . NaO,BrO_5 . . .	Tetrahedrons . . .	. . . .	Efflorescent.

Name of Salts.	Form.	Action of the Air.	
Neutral Carbonate of Soda $NaO,CO_2,10HO$	Large rhomboidal prisms		Efflorescent.
Malate of Soda $NaO,\bar{M}$	Saline mass	Deliquescent.	
Molybdate of Soda NaO,MoO_3	Large crystals		Efflorescent.
Nitrate of Strontia StO,NO_5	Octahedra		Efflorescent.
Perchlorate of Strontia StO,ClO_7	Long prisms	Deliquescent.	
Chlorate of Strontia StO,ClO_5	Needles	Deliquescent.	
Bromate of Strontia StO,BrO_5	Long four-sided prisms		Efflorescent.
Chloride of Thorinium $ThCl$	Crystals	Deliquescent.	

Name of Salts.	Form.	Action of the Air.	
Perchloride of Uranium U_2Cl_3	Quadrangular tables, of a greenish colour	Deliquescent.	
Bromide of Uranium U_2Br_3	Flat needles of greenish colour	Deliquescent.	
Nitrate of sesquioxyde of Uranium U_2O_3,NO_5	Large tables of a yellow colour		Slightly efflorescent.
Chloride of Yttrium Y,Cl	White shining needles	Deliquescent.	
Permanganate of Zinc ZnO,MnO_7	Saline mass	Deliquescent.	
Chloride of Zinc $ZnCl$	Waxy mass	Deliquescent.	
Sulphate of Zinc $ZnO,SO_3,7HO$	Prismatic crystals		Slightly efflorescent.
Chloride of Zirconium Z_2Cl_3	Needles		Efflorescent.

LAWS OF BERTHOLLET.

ACTION OF ACIDS UPON SALTS.

When acids are poured on, or put in contact with salts, the result is either nothing, the salt merely dissolving in the acid but without decomposition, or remaining altogether insoluble in it;
or, else the salt is *entirely* or *partially* decomposed by the acid employed;
or, finally, but more rarely, the acid used combines with the salt on which it is poured to form an acid compound, if the original salt was a neutral one; or to form a neutral compound, if the salt before being submitted to the action of the acid, was a basic one.

The circumstances under which acids can decompose salts, were first resumed by Berthollet, in a series of laws which bear his name, and which are as follows:—

A salt is decomposed by an acid being poured upon it, or put in contact with it:—

I.

When the acid employed is more powerful, that is to say, has a greater affinity for bases, or is more fixed than the one which enters into the constitution of the salt.

Example.—Sulphuric acid poured upon carbonate of potash, decomposes it as follows—

$$KO,CO_2 + SO_3,HO =$$
$$KO,SO_3 + HO + CO_2$$

In this case the sulphuric acid employed is both a more powerful, and a more fixed acid than that of the carbonate.

Again—

$$\overbrace{NaO,2BO_3,10HO}^{\text{Borax}} + SO_3,HO =$$
$$NaO,SO_3 + 11HO + 2BO_3$$

In this case the borax is decomposed, and boracic acid is deposited, because sulphuric acid is a more powerful acid.

But if sulphate of soda, for example, be heated with boracic acid, the salt will be decomposed with an evolution of sulphurous acid, and of oxygen as follows:—

$$NaO,SO_3 + BO_3 =$$
$$NaO,BO_3 + SO_2 + O$$

In this case the boracic acid though possessed of less affinity than sulphuric acid, as was shown in the preceding example, is nevertheless enabled, under the influence of heat, to expel the latter from the salt, and to take its place, because sulphuric acid is a volatile acid, whilst boracic acid is a fixed one.

The production of silicate of potass (glass) is due to a similar reaction; thus—

$$NaO,SO_3 + SiO_3 =$$
$$KO,SiO_3 + SO_2 + O$$

II.

When the acid poured in the solution of a salt can form with the base of that salt an insoluble, or a less soluble compound than the salt operated upon, the latter is decomposed; for example—

$$BaO,NO_5 + SO_3,HO =$$
$$BaO,SO_3 + NO_5,HO$$

III.

When a salt is composed of an insoluble or sparingly soluble acid, and an acid is poured upon it which can form a soluble compound with the base of the salt, the latter is decomposed as follows:—

$$KO,SiO_3 + SO_3,HO=$$
$$KO,SO_3 + SiO_3HO$$

IV.

When an acid of a weak chemical affinity is made to react upon a salt, the acid of which is weak also, that acid which exists in greater proportion expels the other, as follows:—

In large quantity

$$KS + HO + \overbrace{CO_2} =$$
$$KO,CO_2 + \underbrace{HS}$$

expelled.

In the same manner if a current of HS is passed through a current of KO,CO_2, it eventually expels and takes the place of the CO_2, thus—

In excess

$$KO,CO_2 + \overbrace{HS} =$$
$$KS + HO + \underbrace{CO_2}.$$

expelled.

ACTION OF BASES UPON SALTS.

Salts are generally decomposed by contact with bases, which decomposition is, of course, due to the property which bases possess of neutralizing acids, wherefore, the decomposition of salts is so much the more complete as the bases employed have a greater neutralizing power; yet bases in contact with certain salts have no apparent reaction, or merely cause them to dissolve therein, but without decomposition, or else with the production of a basic salt.

SALTS ARE DECOMPOSED BY BASES.

I.

When the base employed is more powerful, that is, has a greater affinity for acids, or is more fixed than the one which enters into the constitution of the salt.

Such are, for example, all ammoniacal salts which, when treated by lime, strontia, baryta, soda, or potash, evolve ammonia, thus—

$$NH_4Cl + CaO =$$
$$CaCl + NH_4O$$
$$NH_4O,SO_3 + KO =$$
$$KO,SO_3 + NH_4O.$$

In these cases the base employed (CaO or KO) is more powerful, and more fixed than the ammonia of the salt.

II.

When the base poured on, or added to the solution of the salt can form with the acid of that salt an insoluble, or a less soluble compound than the salt operated upon, the latter is decomposed; for example :—

$$KO,SO_3 + BaO =$$
$$\underbrace{BaO,SO_3} + KO.$$

Insoluble.

Such is the case also when lime-water is poured into a solution of soluble carbonate, thus :—

$$KO,CO_2 + CaO =$$
$$\underbrace{CaO,CO_2} + KO.$$

Insoluble.

III.

When the base of the salt operated upon being insoluble, the base employed can form a soluble compound with the acid of the salt, the base of the salt is precipitated.

EXAMPLE—

$$MgO,SO_3 + KO =$$
$$KO,SO_3 + MgO.$$

This third law, as may be seen, is the reverse of the second.

IV.

When the base employed has a greater power of saturation than that of the salt, the base of the salt is precipitated (Gay Lussac), thus :—

$$CuO,NO_5 + AgO =$$
$$AgO,NO_5 + CuO.$$

ACTION OF SALTS UPON EACH OTHER.

When the separate solutions of two different salts, capable of acting upon each other, are mixed, the result is a combination of the two salts to form a double salt; or, the two salts mutually decompose each other.

The production of alum, by mixing a solution of sulphate of alumina with one of sulphate of potash, illustrates the first of these reactions, and in such a case, a portion of the alum produced is precipitated, because, in general, double salts are less soluble than each of their constituent salts separately.

We shall see presently examples of mutual or double decomposition.

A reaction may take place between two soluble salts; between a soluble and insoluble salt; and *in the dry way*, between two insoluble salts.

Insoluble salts never react upon each other at the ordinary temperature.

ACTION OF SOLUBLE SALTS UPON EACH OTHER.

Whenever two SOLUBLE salts being mixed can, in decomposing each other, form an *insoluble*, or a sparingly soluble salt, double decomposition always takes place in the wet way and at the ordinary temperature, in such a manner that the acid of the one takes up the base of the other, and *vice versâ*, and the salt less soluble than the other is precipitated, thus :—

$$KO,SO_3 + BaO,NO_5 =$$
$$KO,NO_5 + \underbrace{BaO,SO_3}.$$

Insoluble.

Again—

$$KO,AsO_3 + CuO,SO_3 =$$
$$KO,SO_3 + \underbrace{CuO,AsO_3}.$$

Insoluble.

Again—

$$PbO,NO_5 + NH_4O,\bar{O} =$$
$$NH_4O,NO_5 + \underbrace{PbO,\bar{O}}.$$

Insoluble.

Again—

$$AgO,NO_5 + NaCl =$$
$$NaO,NO_5 + \underbrace{AgCl}.$$

Insoluble.

Whenever *two soluble salts*, being mixed, can, by their mutual decomposition, form one or two soluble salts, no effect is produced at the ordinary temperature, but by applying heat, double decomposition takes place, the least soluble of the two salts depositing first—

nothing in the cold, but by boiling the solutions $= \underbrace{KCl + NaO,NO_5}_{NaCl + KO,NO_5}$.

less soluble deposited.

Again—

nothing in the cold, but by boiling $= \underbrace{NH_4O,SO_3 + NaCl}_{NH_4Cl + NaO,SO_3}$

less soluble deposited.

ACTION OF SOLUBLE SALTS UPON INSOLUBLE SALTS.

All insoluble salts are decomposed by boiling with a large excess, for example, five or six times their weight, of alkaline carbonates, the insoluble salt being first pulverized as finely as possible; the ebullition must be sometimes continued for several hours. The phosphates of earths are the only insoluble salts which cannot be decomposed in that way.

In general when an insoluble salt is heated in the solution of a soluble one, they react upon each other as if they were two soluble salts (though more slowly), when by the exchange of their respective bases they can produce an insoluble one, for example—

Insoluble.

$$\overbrace{BaO, SO_3} + KO,CO_2 =$$
$$KO, SO_3 + \underbrace{BaO,CO_2}$$

Insoluble.

Yet if carbonate of baryta be heated with sulphate of potash, a certain quantity only of KO,CO_2 and of BaO,SO_3 is produced, the decomposition depending upon the quantity of the salts under experiment, the temperature at which the experiment is taking place, and the length of time during which it is carried on. The reaction is always complete in the dry way.

ACTION OF SALTS UPON EACH OTHER IN THE DRY WAY.

In the dry way the reaction of salts upon each other takes place under the following circumstances:—

I.

When by mutually exchanging their bases they can produce a volatile salt, or a salt more volatile than either of them separately.

Example—If a mixture of carbonate of lime and of sal ammoniac be heated in a retort, decomposition takes place and carbonate of ammonia sublimes, thus—

$$CaO,CO_2 + NH_4Cl =$$
$$NH_4O,CO_2 + CaCl$$

In this instance the sublimate takes place because NH_4O,CO_2 is more volatile than the NH_4Cl originally employed.

II.

When two salts can react upon each other so as to form a salt much more fusible than either of them separately, double decomposition generally takes place.

For example, a mixture of CaCl and of BaO,SO_3 is converted by fusion into BaCl and CaO,SO_3, because BaCl is more fusible and more dense than CaCl.

III.

When the metallic chlorides of the metals of the last sections (see p. 4) *are poured in the solutions of the protochlorides of the metals of the first sections, the former are always reduced.*

The same reaction takes place when the solutions of two metals are mixed, one of which has more affinity for oxygen than the other, the last being, of course, reduced—such is the reduction of gold solutions by proto-salts of iron.

ACTION OF METALS UPON METALLIC SOLUTIONS.

The solutions of the salts of the first and second section (see p. 4) cannot be reduced by metallic bars.

Antimony. According to Mr. Fisher, may reduce the carbonate and nitrate of silver to the metallic state.

Bismuth. According to Mr. Fisher, may precipitate metallic gold from solution of chloride of gold, and metallic silver from carbonate and nitrate of silver.

Copper. Reduces to the metallic state the acid solution of salts of silver; the silver is precipitated in a spongy mass, or in small crystals.
Metallic gold from the muriatic acid solution of chloride of gold.
The salts of mercury. The bar of copper, upon being rubbed, assumes a silvery appearance, which disappears by heat.
The salts of arsenic. A film of metallic arsenic is deposited on the copper.

Tin. Precipitates gold from its solutions in the state of a powder of a purple or pinkish colour in dilute solutions; in concentrated solutions the powder is black.
In solutions of antimony a black precipitate of metallic antimony, which is mixed with oxyde of antimony, if free nitric acid exists in the solution.
In solutions of tungstates, a blue precipitate.
Precipitates silver from solutions of salts of silver.
Precipitates copper from its solutions in nitric, muriatic, and sulphuric acid, but it has no action of ammonia-sulphate of copper.

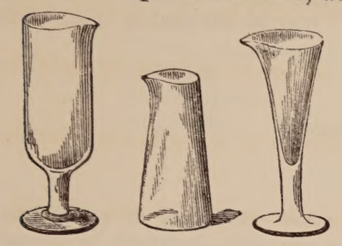
Iron. Precipitates the solutions of the oxydes of gold, of silver, of copper, of tellurium, of antimony, in the metallic state. In a solution which contains selenious acid, red, brown, or blackish flakes of selenium are gradually deposited.

Lead. Precipitates metallic gold from solutions of chloride of gold.
Ditto the salts of silver.
Ditto the double salts of silver and ammonia.
Ditto nitrate of copper.

Zinc. Precipitates copper, silver, tin, tellurium: the solutions of these salts must contain an excess of acid.
Also antimony, cadmium, platinum, palladium, rhodium, iridium, gold—from their acid solutions.
Zinc filings reduce chloride of silver by means of dilute sulphuric acid; the hydrogen combines with the chlorine, and the metal is set at liberty; by washing the silver it is then obtained pure.
Reduces arsenic acid into metallic arsenic.
Selenious Acid. Red, brown or grey, or blackish flakes are gradually precipitated (selenium) according to temperature.
In acid solutions of tungstic acid, fine blue colour due to formation of WO.

APPARATUS.

I have already said that the operations of chemical analysis require only a small number of apparatus and utensils. In my edition of Rose's masterly treatise, published several years ago, a list was given of the most important articles, which I reproduce here, with several modifications and additions.

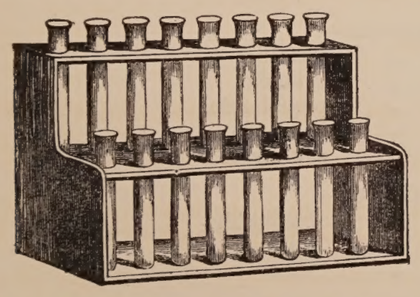


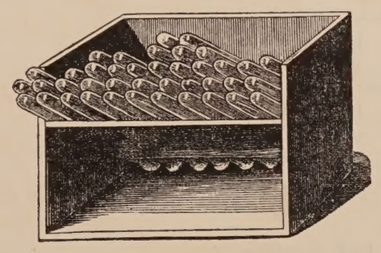
The most indispensable of these articles for operating in the wet way are SMALL GLASSES in which the substances under examination, may by dissolved, or else in which the solutions of the substances may be tested by submitting them to the action of the reagents. The glasses ordinarily employed are similar to those called champagne glasses. The best forms of test glasses are represented here. The middle one, known under the name of Philipps's precipitating glass, is exceedingly convenient for allowing precipitates to subside. The two other forms are best adapted for testing. It is impossible, however, to heat the liquor contained in such glasses, which is an inconvenience, because it is necessary to apply heat in almost every case of qualitative analysis; wherefore it is much preferable, in my opinion, to use test-tubes. For this purpose glass tubes must be chosen not too thick, and they are to be cut in lengths double that which it is intended that the test tube should have, after which they are each to be heated in the middle by means of the enameller's blow-pipe, and when the glass has softened, the extremities are to be drawn, by which means two tubes are obtained of an equal length, and almost closed at one end. That almost closed end is to be well fused, and then gently blown, so as to render it hemispherical. The upper part or open end of the tube may now be heated likewise before the enameller's blow-pipe, in order to turn the rim slightly over for the purpose of facilitating the transferring of liquids. The most convenient size for test tubes is about five inches in length, by three-quarters of an inch in diameter; they should be made of thin German glass, and well annealed, so that boiling hot liquids may be poured into them without fear of cracking them.

Solutions, as well as their precipitates, may be readily heated, or even boiled in such tubes, provided the closed end of the tube be of a uniform thickness. It often happens while heating in these tubes liquids in the midst of which an insoluble precipitate has been formed, that the liquor boils up so violently, that a great portion of the liquid and of the precipitate is projected out of the tube with almost explosive force, which is not even without danger to the operator. Such glasses must not be employed in those cases except for experiments in which it is not imperative to apply heat. Whenever it is necessary to boil a liquid, the orifice of the tube must be inclined in such a direction that the portions which might be projected may not prove hurtful.

About twenty such tubes are required, which may be placed in two tiers, in a frame, as here represented; the tubes of the lower tier are a little larger and longer than those of the upper one.

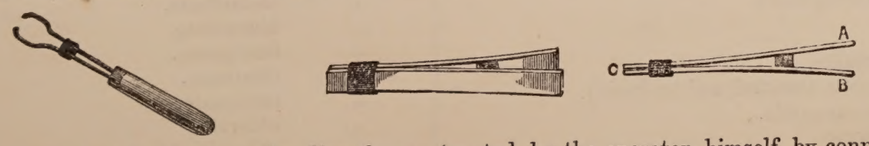
The following tube-box, however, will be found, I





think, more convenient, as it is capable of holding a much larger quantity of tubes. The operator should have two such tube-boxes, one to contain the clean tubes, which should be placed mouth downwards, so that they may remain clean; the other to contain the tubes which have been used, and which are at once deposited therein, of course with their mouths upwards.

The tubes may be held, whilst boiling, by means of a tube-holder represented in the following figure;



but a most convenient holder may be directly constructed by the operator himself by connecting two strips of wood, placed parallel to each other, with a ring of vulcanized caoutchouc, and introducing a piece of cork between them, as represented here. In pressing A and B together, the extremity C opens and is ready to grasp the tube, flask, or other utensils too hot to be held with the naked hand.

As the phenomena which the reagents determine in the solutions of the substances under examination are not always produced immediately, but, on the contrary, require a certain lapse of time to become manifest, the solution, after mixing with the reagent, should be left at rest; and in order to avoid committing errors, the name of the reagent, added to the solution in the glass, should be written upon gummed paper, and pasted upon it. As common ink is liable to be obliterated or discharged by acids, &c., it is better to employ a lead pencil, but hard black chalk is the best.

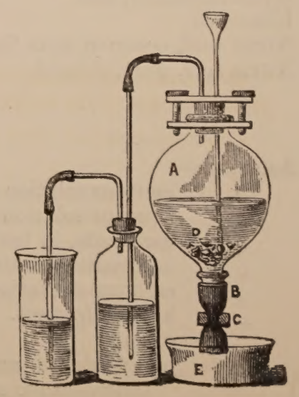
It is advisable to have a separate apartment for precipitations by means of sulphuretted hydrogen, or of hydrosulphuret of ammonia, and it is absolutely necessary to perform such experiments under a strong draught of air, in order to get rid of the noxious vapours. This precaution should never be neglected, not only because the odour of sulphuretted hydrogen is exceedingly disagreeable, but also because it may prove extremely injurious to health. The experiments with the other reagents may generally be conducted in a common room.

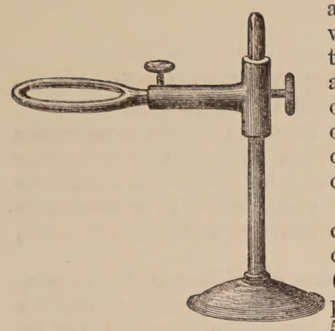
Instead of the glass test tubes above alluded to, and especially when the quantity of liquid is too large to be put into a tube, small mattrasses may be used for boiling liquids. Florence flasks are extremely useful utensils for the purpose, and in order to be able at all times to handle them, even when very hot, I would recommend putting round the neck of the mattrass or flask a piece of vulcanized caoutchouc cut from a tube of a suitable size. The explosive boiling of which we have already spoken, is less liable to take place in such utensils; or else the boiling may be conducted in glass beakers placed upon a wire-gauze.

Glass funnels are also required, and likewise paper filters, in order to collect precipitates, and a certain number of ordinary glasses or beakers of various sizes; a few watch-glasses, a few tubulated bottles for disengaging sulphuretted hydrogen, carbonic acid, &c. Ordinary bottles, provided with sound corks fitting tight, and which may be perforated with the necessary number of holes for the reception of the tubes of disengagement, funnel, &c., answer the same purpose. The apparatus thus constructed, has, however, the inconvenience of not being easily portable, and of requiring to be mounted every time it is wanted. To remedy this I used to employ in my laboratory the following contrivance, which, though I have replaced it since by a still more convenient apparatus, described below, may yet be found useful when the other is not come-at-able:—

A is the bottle containing the protosulphuret of iron, water, and sulphuric acid, and provided with a funnel and disengagement tube as usual, the latter plunging in the water of a smaller bottle, B, from which a disengagement tube, D, nearly as high as that of bottle, A, issues, so as to lead the gas disengaged in a beaker or other vessel containing the liquor to be operated upon—but the first disengagement tube, C, is in two pieces, united by vulcanized Indian rubber, and the bottles, A B, are connected together by a strong band of sulphurized Indian rubber, G, so that the two bottles may be lifted at once as if it were one bottle, wedges of cork, E E, being forced between the two bottles so as to keep the strip of Indian rubber, G, and the tube, C, properly adjusted.

The accompanying apparatus here represented, which I contrived about two years ago, and which I have had in constant use ever since, will, however, be found more convenient than that described above. It consists of a bottle A, open at both ends; the upper end, which is larger, is provided with a sound cork, glued with marine glue to a piece of wood, so that it may be screwed down air-tight. This cork is provided with the usual funnel and disengagement tubes. The lower end is provided with a tube of vulcanized india rubber, B, which is squeezed tight by means of a clip, C. When it is wished to make use of the apparatus, the operator first removes the cork by unscrewing the screws, and he then introduces into the bottle, A, a certain quantity of protosulphuret of iron, in lumps, D, and he then replaces the cork, and screws it down, so that the bottle may be air-tight; sulphuric acid suitably diluted being now poured into the bottle through the funnel, a disengagement of sulphuretted hydrogen takes place as usual. The advantage of the arrangement is this, that on opening the clip, and therefore, opening the tube, B, the whole of the acid may at once be removed and collected into the beaker or receiver, E, placed underneath, so that the apparatus need not be kept in operation one moment longer than necessary. It may be washed with the utmost ease,





and is always ready for use. The bottle, A, is supported in any convenient way; but I prefer the ring of a retort stand, modified as represented in the accompanying figure. Indeed, I have adopted this form of rings for all the stands in my laboratory, because they present the great advantage of being easily and at once removed and replaced by rings of a larger or of a smaller diameter, and of enabling the operator to use them as ordinary rings, and likewise as supports for the necks of retorts or of other apparatus, by screwing them on vertically, or at any suitable angle.

The other necessary utensils are, a small spirit-lamp with a ground glass-cover, and a large spirit-lamp with circular wick (Berzelius's spirit-lamp), or my blowpipe-lamp furnace, described in the Preliminary Observations (page vi.) for cases in which a more intense heat is required—a strip of platinum foil; a small and thin platinum crucible capable of holding about 500 grains of water; several small porcelain crucibles of the same size as above; several porcelain evaporating dishes; a small agate mortar with its pestle; several small glass tubes; a syringe bottle; a few watch-glasses. A few glass retorts and receivers are also required in some cases. The description of all these utensils may be found in Berzelius's treatise, to which the reader is referred. Berzelius's admirable work, however, has never been translated into English.

I cannot terminate this short list of instruments without mentioning the little utensil for cleaning glasses and tubes, and which, I am sure, will be found of the utmost service, as it enables the operator to perform with ease, one of the most tedious parts of the work of the laboratory; it is cheap, easily kept clean, most effective, and can be constructed in five minutes: it is simply a piece of stout iron wire, or of cane, passed through a tube of vulcanized caoutchouc, and tied thereto, but so as to project beyond the wire, or stick, about a quarter of an inch. As vulcanized caoutchouc tubes are found in commerce of almost all sizes the "caoutchouc cleaner" may be adapted to tubes of all dimensions.

I have said that the blow-pipe is an indispensable instrument in most operations of qualitative analysis. Both the instruments and the utensils which its use requires, are fully described in special treatises. A more complete list of the apparatus and utensils which may be required will be found at the end of the book.

REAGENTS.

The reagents employed in chemical aalysis are not very numerous, and a list of those which are sufficient for all ordinary purposes will be found here below. A certain arrangement should be adopted in placing them on the shelves of the laboratory in order that the operator may be enabled at once to lay his hand upon the reagent which he may have occasion to use. The most convenient plan perhaps, consists in putting under the head of each base or metallic oxyde, and in alphabetical order, all the salts and compounds thereof employed as reagents; all the acids should be put by themselves and in alphabetical order as follows:—

Acetic acid.
Aqua regia.
Arsenious acid.
Benzoic acid.
Boracic acid.
Hydrochloric acid, ordinary.
Hydrochloric acid, pure.
Hydrochloric acid, diluted.
Hydrofluosilicic, acid.
Iodic acid.
Nitric acid, common aqua fortis.
Nitric acid, pure, diluted.
Nitric acid, fuming.
Nitropicric acid.
Oxalic acid.
Phosphorous acid.
Phosphoric acid.
Silicic acid.
Succinic acid.
Sulphuric acid, concentrated.
Sulphuric acid, diluted.
Sulphurous acid.
Tartaric acid.

AMMONIA—
„ aqueous solution of ammonia, fortissima.
„ aqueous solution of ammonia, diluted.
„ carbonate, in lumps.
„ carbonate, solution.
„ carbonate, solution mixed with ammonia.
„ hydrosulphuret.
„ oxalate.
„ phosphate of ammonia and of soda, (microcosmic salt.)

Ammonia—sal ammoniac, in lumps.
„ sal ammoniac, in solution.
„ succinate.

BARIUM—
„ acetate.
„ baryta water.
„ carbonate.
„ chloride.
„ nitrate.

CALCIUM—
„ carbonate.
„ chloride.
„ hydrate.
„ hypochlorite.
„ lime water.
„ sulphate.

COBALT—
„ nitrate.

COPPER—
„ metallic.
„ oxyde.
„ protosulphate in crystals.
„ protosulphate in solution.

GOLD—
„ leaf, metallic.
„ perchloride.

IRON—
„ metallic.
„ perchloride.
„ protosulphate in crystals.
„ protosulphuret.

LEAD—
„ metallic.
„ acetate (neutral and tri-basic).
„ brown oxyde.
„ nitrate.
„ protoxyde.
„ red lead.

MAGNESIUM—
„ carbonate
„ hydrate.
„ sulphate.

MANGANESE—
„ peroxyde.

MERCURY—
„ metallic.
„ cyanide.
„ perchloride.
„ peroxyde.
„ subnitrate.

PLATINUM—
„ bichloride.
„ foil.
„ wire.

POTASSIUM—
„ metallic.
„ acetate.
„ antimoniate.
„ bicarbonate.
„ bichromate.
„ binoxalate.
„ bisulphate.
„ bitartrate.
„ carbonate.
„ chlorate.
„ chloride.
„ chromate.
„ cyanide.

Potassium—
- „ ferrocyanide.
- „ ferricyanide.
- „ iodide.
- „ nitrate.
- „ potash, pure à l'alcohol, and in lumps.
- „ potash, solution.
- „ silicate, basic, solution.
- „ sulphate.
- „ sulphocyanide.
- „ sulphuret.

Silver—
- „ nitrate.
- „ sulphate.

Soda—
- „ acetate.
- „ biborate (borax).
- „ bicarbonate.
- „ carbonate.
- „ phosphate.
- „ succinate.

Soda—
- „ sulphate.
- „ sulphite.
- „ sulphuret.

Tin—
- „ metallic, foil.
- „ protochloride.

Zinc—
- „ metallic.

Distilled water.
Alcohol.
Ether.
Test papers.
Charcoal, vegetable.
Charcoal, animal.
Tincture of galls.
Tincture of litmus.
Tincture of turmeric.
Sulphate of indigo.
Starch.

TABLES.

PRELIMINARY PROCESSES.

TABLE I.—A.

Preliminary Processes and Tests for detecting the probable CONSTITUENTS of COMPOUNDS.

The Substance is in the solid state, but is NOT a METAL, NOR an ALLOY.

Reduce the substance to as fine powder as possible (if in compact masses break off a few grains of it), pulverize, and introduce a small portion of the powder into a small glass test-tube, perfectly free from lead (Observation a), and expose it therein, at first, *to a very gentle heat*, over the flame of a spirit-lamp, then gradually increase the heat to redness, holding the tube at an angle of about 30° or 40°.

O.

Go to TABLE I.—B.

WATERY Fusion.

Presence of a salt containing water of crystallisation.—Introduce a piece of grey litmus paper in order to ascertain whether the condensed water is ACID, ALKALINE, or NEUTRAL.

If *acid*, presence of a volatile acid, or of acid salts (a few neutral salts behave in the same manner). If *alkaline*, possible presence of NH_3. Transfer the dry residue to a strip of platinum foil and expose it thereon to a bright red heat; if it fuses, then go to cols. 3, 4, 5, 6, 7. If it does not undergo secondary fusion go to TABLE I.—B., especially cols. 5 to 11, and TABLE I.—C. and D. Observ. b.

FUSES, but emits little or NO Aqueous Vapour.

Throw a small piece of paper, or a splinter of charcoal, into the mass whilst in a state of fusion.

DEFLAGRATION. (Observations c.)

Nitrates. Bromates.
Nitrites. Iodates.
Chlorates. Permanganates.
Perchlorates.

Mix a small portion of the well-pulverized compound, with about twice its bulk of KO, $2SO_3$, and expose the mixture to the heat of a spirit-lamp in a glass test-tube.

Ruddy Fumes.	ODOUR of Chlorine.	Violet Fumes of Iodine.
Nitrates. Bromates. In the case of Bromates, the fumes are often imperceptible, except by looking down the tube, whilst the odour resembling Cl may be erroneously attributed to that substance.	Chlorates.	Iodates. A black sublimate of I, condensing on the cold sides of the tube, an odour of SO_2 is perceptible.

Take another portion of the well-pulverized compound, put it into a glass test-tube, add a few drops of concentrated SO_3 HO in the COLD.

White Fumes of NO_5.	Hyacinth red Fumes of Br.	Greenish Yellow Fumes of ClO.	O.
Nitrate. Observ. d.	Bromate.	Chlorate. The first impression of the SO_3 HO imparts to the compound a deep yellow colour.	Iodate. Put another small portion of the compound in a test-tube, with solution of starch, and add some NO_5. **Blue Colour.** Iodate. Observ. e.
Nitrate.	Bromate.	Chlorate.	Iodate.

NO Deflagration.

Examine the compound according to the directions given in TABLES I.—B. I.—C. I.—D. I.—E.

Black by charring.

Almost certain presence of Organic Matter (Observ. f.). Fuse a little KO,NO_5 in a test-tube, and when in a state of fusion project a little of the pulverized substance into it.

DEFLAGRATION.

Certain presence of organic matter. (Observations g.) If the compound whilst charring evolved an odour of

Burnt Sugar, Tartaric Acid, Tartrates,
Cyanogen or Bitter Almonds, or of Ammonia } Cyanides.
Pungent Acid Fumes { Citric Acid, Citrate, Malic Acid.
Benzoïn . . Benzoïc Acid.
Acetone . . Acetates.

(Observations h.)

If a lighted match being held at the mouth of the tube whilst the substance is heated *per se*, the gas or fumes evolved burn with a flame of a

Peach Blossom Colour.	Clear Yellow.	Blue.
Probably Cyanide. The Cyanides of the noble metals only have this character. Observ. i.	Probably Acetate. Observ. j.	Probably Oxalate Formiate. Observ. k.
Cyanide.	Acetate.	Oxalate Formiate.

VOLATILISES PARTLY or COMPLETELY with or without Previous Fusion.—A SUBLIMATE is generally formed. (See Observ. l.)

NO ODOUR.

Sulphur.

Salt of NH_3	Observation m.	
Hg.	do.	
Chloride of a fixed base.		
Oxyde of Sb.	Observation m.	
do. Te	do.	
Acids AsO_3	do.	
AsO_5	do.	
Metals Te.	do.	
Cd.	do.	
Hg.	do.	

AN ODOUR is evolved (Observ. n).

The odour evolved is often quite characteristic; thus—		
Odour of Bitter Almonds	...	Cyanogen or its compounds.
do. Sulphurous Acid (Observations o)	...	Sulphur.
do. Garlic	...	Arsenic.
do. Decayed Raddish	...	Selenium.
do. Benzoïn	...	Benzoïc Acid.
do. Burnt Sugar	...	Tartaric Acid.
do. Ammonia	...	Ammonia.
Pungent, white, heavy, suffocating acid fumes (Observ. p)	...	Sulphuric Acid.
Disagreeable odour, resembling that of Chloride of Sulphur, inducing cough, and irritating the nose and eyes	...	Osmic Acid.

But whether or not, An Odour is evolved, if the SUBLIMATE in the cold part of the tube is

Yellow.

$S—AsS_3—AsS_5$ HgI.

If the compound fuses into drops, or into a liquid of a	Mix a portion of the original compound, or of the yellow sublimate, with one part of NaO, CO_2 + two parts KCy, and heat a portion of the mixture in a small German test-tube, closed at one end, as described in the tests for AsO_3. (See the Dictionary.)	If the compound before heating was
Reddish Brown Colour. becoming thick, and which long after cooling becomes	Metallic Mirror.	**Red,**
Yellow, and which being set fire to, burns with a characteristic blue flame, and an odour of SO_2, it is	AsS_3 AsS_5. Observat. y, col. 22.	and if the yellow sublimate produced, being triturated becomes again
S. Observ. q.	AsS_3 AsS_5.	**Red.** HgI. Confirm by fusion with NaO, CO_2 to obtain globules of Hg, as described in col. 17. Observ. r.
		HgI.

White, possibly with a tinge of Yellow. | Grey.

AsO_3—Sb_2O_3 certain salts of NH_3 and of Hg—possibly also TeO_2—OsO_4, &c. (Observations s.)

If the tests below do not show the presence of the above substances in a satisfactory manner, go to TABLE I.—B.

Take a fresh portion of the compound, or some of the white sublimate, and introduce it into the end of a small German tube, drawn to a point, put on the top of it a fragment of charcoal, heat the charcoal first, and when red hot, heat at once the end of the tube containing the sublimate.	Drench a fresh portion of the compound, or of the sublimate, with solution of KO, and triturate the mass.	If the sublimate *did not fuse* when heated, and whilst hot had a	If the sublimate *fused* at a moderate heat, and was most easily volatilized, and was WHITE both when hot and when cold, probable presence of HgCl. Confirm by mixing a fresh portion of the compound with NaO, CO_2, slightly moistening the mass and heat it in a glass tube *with the blowpipe*.
Metallic Mirror.	Odour of NH_3.	**Slight Yellow tinge,**	Globules of Metallic Mercury.
AsO_3. Submit it to the other tests related under the head of AsO_3. (See Dictionary.)	Presence of a salt of NH_3. Observ. t. Go to TABLE I.—B. for the detection of Sb_2O_3	was completely volatile, and on cooling became **White again.**	Observat. u. The mixing of the compound with NaO, CO_2 causes the mass to turn **Reddish Brown.**
AsO_3.	NH_3.	Hg_2Cl. Confirm by fusing with NaO, CO_2, as described in col. 17. See Observ. u, col. 17. Hg_2Cl.	HgCl.

Red. | Orange.

HgS—AsS_2—AsS_3—Se.

The colour is rendered more distinct by trituration.

Fuse a portion of the compound with NaO, CO_2 as just said in col. 17.	Mix a portion of the original compound, or of the sublimate, with one part of NaO, CO_2 + two parts of KCy exactly as described in col. 12.	Fuse a portion of the compound with NaO, CO_2 upon charcoal, with the blowpipe.
Globules of Metallic Mercury.	Metallic Mirror.	Odour of Decayed Raddish.
HgS.	Odour of Garlic. See the tests for compounds of As in the Dictionary, and observ. y. col. 22.	Se. (Observ. v.)
HgS.	AsS_2. AsS_3.	Se.

Black. | Grey.

HgS—AsS_2—AsS_3—Se.

The black sublimate produced by HgS has a metallic appearance. Globules of mercury may be obtained by treatment with NaO CO_2, as described in col. 17. (Observ. x.)	The black sublimate produced by As has a metallic appearance, and the presence of As may be identified by treatment with NaO, CO_2 + KCy, as described, cols. 12—14. (Observ. y.)	When seleniurets are in sufficient quantity the sublimate is black, but by trituration it becomes red. The presence of selenium is, besides, recognised by the odour of decayed horse-raddish, evolved by treatment with NaO, CO_2 before the blowpipe on a charcoal support. (Observ. z.)
HgS.	AsS_2 AsS_3 AsS_5	Se.

DOES NOT VOLATILISE, and the powder is

White | Red | Drab | Yellow.

Which, on applying heat, becomes more or less

Yellow. | Brown.

Probable presence of
ZnO, PbO_2,
BiO, HgO,
PbO, PbO, CrO_3,
TiO_2, and a few other chromates.

If after cooling the substance becomes

White.	Or remains Yellow.	Red again.
ZnO TiO. Other substances behave in the same manner, but none so distinctly as the above. Go to TABLE I.—B.	BiO—PbO. Go to TABLE I.—B., cols. 15, 16, 17. PbO, CrO_3.	HgO PbO_2. Test for HgO, by fusion with NaO, CO_2, as described in col. 17. Test for PbO_2 as described in TABLE I.—B., col. 15.
TiO ZnO.	BiO PbO.	HgO PbO_2

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

OBSERVATIONS ON THE TABLES.

OBSERVATIONS ON TABLE I.—A.

Groups 1 *and* 2.

a. The test-tube employed should be of German glass, or free from lead, since otherwise the red heat employed, by reducing the lead of the tube, will render it black, and stand in the way of correctly observing the reaction.

b. Do not mistake for watery fusion the film of water which condenses on the cold side of the tube, and which is due to the hygrometric moisture which all powders spontaneously absorb. The small quantity of water which is sometimes observed to condense on the cold sides of the tube is not very difficult to identify as water of combination, of interposition, or decrepitation, or as water of absorption (hygroscopic moisture). In effect, hygroscopic moisture is expelled at a much lower temperature than water of combination or of interposition: in fact, the first impression of the heat is sufficient to expel it, whilst it is only after a little time that water of combination, of interposition, or decrepitation, is given off. The water which is expelled by a heat of 212° Fahr. is hygroscopic water, or water of crystallisation, that which resists that temperature, and is only expelled by an increased heat, should be looked upon as combination-water. Water of crystallisation is readily distinguished from hygroscopic water by its abundance. The salts which decrepitate strongly are generally anhydrous salts.

Sometimes the immediate fusion of the substance under the first impression of the heat employed may be mistaken by the inexperienced for a watery fusion; such is the case, for example, with corrosive sublimate (HgCl), which immediately fuses and boils when heat is applied, and then volatilises. Watery fusion is always attended with a somewhat abundant condensation of water on the cold sides of the tube.

With respect to the *alkaline* reaction exhibited on reddened litmus-paper by the condensed water on the sides of the tube, the operator must be very guarded in his conclusions, since instead of being due to a liberation of ammonia (NH_3), it may be caused by portions of the substance operated upon being mechanically projected, and which, should the substance itself have an alkaline reaction, would simulate the presence of ammonia.

If a sublimate accompanied the watery fusion, it is generally a sign of the presence of an ammoniacal salt, in which case Col. 15 should be carefully attended to.

An *acid* reaction of the condensed water in the tube on blue litmus-paper is generally due to the presence of acid salts, or of volatilisable acids, which, under the influence of the heat, part with a portion of their acid. A small number of neutral compounds of these volatilisable acids (amongst which are many neutral nitrates) are thus decomposed when heated in a test-tube, and, yielding a portion of their acid, turn blue litmus-paper red. Generally speaking, however, the heat required to produce that effect must be greater than that which produces watery fusion.

The strip of litmus-paper employed to try the reaction of the water condensed in the tube should be moistened previous to its introduction.

Groups 3 *to* 7.

c. Deflagration will only give the operator a clue to the nature of the acid, or of the non-metallic constituent of the compound under examination, but it will of course scarcely give him any insight into the nature of the base, wherefore, after having endeavoured to ascertain what the acid or non-metallic body may be, he should examine the substance as directed, Cols. 8 to 26, and if not successful then, that is, if the tests there given do not apply, he should go to TABLE 1 B, and thence to TABLE 1 D. If ruddy fumes of nitrous acid are evolved when the mass is thrown into the nitre in a state of fusion, it is a proof that the mass contains a sulphate.

d. When nitrates are treated in the cold by concentrated SO_3, some little time is often required for the white fumes to appear, and if the nitrate be one of a base which forms insoluble salts with sulphuric acid, as for example, nitrate of barytes, a considerable time often elapses before any white fumes, or odour of nitric acid, are perceived. The contents of the tube should be well shaken from time to time.

e. If an iodate is present, violet fumes, will have been produced, by the previous treatment with $KO,2SO_3$.

Groups 8 *to* 10.

f. Several substances, on being heated as directed, turn black, though the colour is not due to charring. Whether or no charring has taken place is shown by throwing it into fused nitre. If the substance, having turned black when heated separately, deflagrates when thrown into fused nitre, then the blackness was due to charcoal, and of course an organic substance is present. If, on the contrary, the substance having turned black by exposure to heat, does not deflagrate when thrown into fused nitre, then it should be treated as under Col. 7, headed "NO DEFLAGRATION," and the operator goes to TABLE 1 B accordingly.

Most organic substances, or compounds containing an organic constituent, become black from charring by exposure to a red heat in a glass test-tube, as we just said; yet there are some exceptions; such is the case, for example, *with the volatile organic acids in the free state*, which often are volatilised without decomposition, and consequently without charring. When, however, these volatile organic acids, instead of being in the free state, are combined with fixed inorganic bases, they are generally charred by exposure to a red heat in a glass test-tube. There are, however, a few exceptions even in that case. Deflagration by projecting the substance into nitre in a state of fusion (when that substance is not sulphur, or a metallic sulphuret, and has turned black when heated *per se* (see observation *g*) is quite characteristic of the presence of an organic body.

If the residue left in the test-tube after charring effervesces when treated by an acid, it is a carbonate, and this indicates that an organic acid, combined with an alkali, or with an earth, is probably present; or else, if the ignition has been protracted, it may be due to the presence of a cyanide, which has thereby been decomposed into carbonate of alkali.

If the effervescence, produced by the addition of the acid to the ignited mass in the tube, is accompanied by an odour of cyanogen, of course a cyanogen compound is present, and the addition of a little potash, a drop of Fe_2Cl_3, and supersaturation with HCl, will produce a blue colour (Prussian blue).

g. Several substances besides those of an organic nature deflagrate when thrown into nitre in a state of fusion, such are, for example, sulphur and the metallic sulphurets, when finely pulverised, tellurious and osmic acids, but the property of being charred when heated separately, and of deflagrating when thrown into nitre in a state of fusion, is perfectly characteristic, and does not belong to any other substances but those of an organic nature.

h. If the substance is greenish, or dark green, or violet, or red, or black, and being thrown into fused nitre, forms a deep yellow mass (KO,CrO_3), producing, when dissolved in water, a yellow solution, chromium is probably present, and the yellow solution contains chromate of potash. All the salts of chrome fused with KO,NO_5 behave in the same manner.

i. The charring of cyanides is often accompanied by an odour of cyanogen (bitter almonds) and of ammonia, and sometimes of ammonia only, the cyanogen and the water of combination of the compound undergoing decomposition, so as to form ammonia and a formiate; several cyanides are not charred by exposure to a red heat.

j. All acetates are decomposed by heat. The acetates of alkalies, or of alkaline earths, evolve acetone (C_3H_6O), which burns with a yellow flame, the residue being a carbonate of the base which, of course, effervesces if an acid is poured upon it. The other acetates evolve a mixture of acetic acid, of carbonic acid, and of acetone, the base being left behind in the state of a pure oxyde, or of a pure metal, and consequently the treatment of the residue by an acid is not then accompanied by any effervescence.

The presence of an acetate is immediately detected by pouring some concentrated sulphuric acid (SO_3HO) upon the substance, and applying heat, the characteristic odour of acetic acid being then evolved.

k. The formiates of alkalies, and of earths exposed to a red heat in a glass test-tube, emit inflammable gases which, somewhat like oxyde of carbon, burn with a blue flame. The formiates of easily reducible metallic oxydes evolve a mixture of hydrocarburets and of carbonic acid, a residue of charcoal and the pure metallic oxyde being left behind.

Groups 11 *to* 23.

l. Pay particular attention to whether the substance *fuses* before volatilising, as this may prove a distinctive character; thus, for example, perchloride of mercury (corrosive sublimate, HgCl), fuses before volatilising, whilst subchloride of mercury (calomel, Hg_2Cl) is volatilised, but does not fuse.

m. Most of the *salts of ammonia* are sublimed without undergoing decomposition, unless their acid be a fixed one.

If the sublimate is one of a *salt of mercury*, a drop of ammonia will generally turn it black; but the best way is to mix the compound with NaO,CO_2, and then heat it in a test-tube. If mercury is present, globules of metallic mercury are produced, or may be rendered apparent by rubbing the sublimate so obtained with the end of a glass rod, or a strip of cardboard moistened with water.

Oxyde of antimony sublimes, but does not fuse, whilst *oxyde of tellurium* fuses before subliming.

Arsenious acid gives a white sublimate, which, examined with a magnifying glass, is found to consist of hexaedral crystals.

Arsenic acid produces a white sublimate of arsenious acid, but oxygen is at the same time evolved, which may be identified, because a glowing taper is rekindled when plunged into the tube.

If an *organic matter* is present along with $As O_3$ or As,O_5, an odour of garlic will be perceived.

Metallic tellurium requires a very strong heat to sublime, such as can hardly be attained, except the flame be urged by the blow-pipe.

Cadmium gives a yellowish-brown sublimate.

Mercury gives metallic globules.

Arsenic an odour of garlic, and a metallic mirror.

n. In endeavouring to ascertain whether any odour is emitted whilst heating the substance, the operator must bear in mind that *some fumes are exceedingly deleterious*. He should therefore take care not to keep his nostrils for any great length of time over the mouth of the tube. It is sufficient to pass the tube rapidly under the nose to detect any odour which may be given off.

o. If the substance under examination contains a hyposulphate, an odour of sulphurous acid (SO_2) will be evolved on heating it in a glass test-tube, because these salts are thereby decomposed. The heat of the spirit lamp is quite sufficient for the purpose, and the odour is characteristic of their presence, a sulphate being left in the tube.

p. If the fumes are very thick, white, and heavy, and have an acid reaction on moistened blue litmus-paper, the probability is that they are due to sulphuric acid, and consequently the substance is a sulphate, which may be summarily confirmed by mixing the substance with carbonate of soda, and fusing on charcoal in the deoxydising, or inner blue flame of the blow-pipe. The scories, if any are left on the charcoal, or a piece of the charcoal itself, if the mass have been absorbed by it, should then be placed upon a piece of silver, and moistened thereon with one drop of dilute hydrochloric acid (HCl); if the piece of silver turn brown, and if the acid emit an odour of rotten eggs (HS), the substance was a sulphate. If the mass have been absorbed by the charcoal during the treatment before the blow-pipe, the substance is a sulphate of alkali. This reaction is quite characteristic.

q. The reddish-brown colour resulting from the fusion of sulphur frequently takes a long time to become entirely yellow after cooling, especially if the heat applied has been strong; some of the fused parts retain for days, and even weeks, a more or less orange-yellow colour, somewhat resembling that of sulphuret of antimony, produced in the wet way. As the fumes of sulphur are very heavy, the yellow sublimate is best obtained by holding the tube quite horizontally, or even with its mouth slightly inclined downwards, as here represented, the yellow sublimate will then settle from A to B, and if sufficiently abundant, the fumes may be inflamed at the orifice B. At any rate, a small portion of the sublimate may always be scraped off with the blade of a knife, and inflamed thereon, so as to obtain the characteristic flame and odour of burning sulphur.

A sublimate of sulphur may be produced by a partial desulphuration of a metallic sulphuret, as, for example, bisulphuret of iron, of tin, of copper. The yellow sublimate may also be due, not to sulphur, but to the volatilisation of a metallic sulphuret, in which case the metal must be of a volatilisable nature, since these metals, which are not volatile, form sulphurets which are not volatile, whilst the sulphurets of volatile metals are volatile also.

r. In order to ascertain whether the YELLOW sublimate produced by iodide of mercury (HgI) turns red again by trituration, it is sufficient to rub the sides of the test-tube with the end of a glass rod. A red streak is produced wherever the rod rubs the sublimate.

The presence of mercury (Hg) had better be confirmed by heating a portion of the substance with carbonate of soda (NaO,CO_2), in order to obtain globules of mercury (Hg), which of course place the existence of that metal beyond doubt.

s. *Arsenious acid* sublimes in a white powder, which is very volatile.

Arsenic acid, under the influence of a stronger heat, parts with a portion of its oxygen, and being thereby converted into arsenious acid (AsO_3) sublimes then readily, like the latter.

Metallic arsenic sublimes and forms a metallic mirror, which may be shifted from place to place within the tube, yet some care is required, since it becomes gradually changed into arsenious acid (AsO_3), and thus, instead of a metallic mirror, the operator soon converts it, by repeatedly heating and volatilising it, into a white, easily volatilised, sublimate, which is arsenious acid (AsO_3).

Certain metallic arseniurets yield metallic arsenic when thus heated in a glass test-tube. The odour of garlic is produced only by *metallic* arsenic.

Sesqui-oxyde of antimony (Sb_2O_3) fuses first into a yellow liquid, and a continued application of the heat volatilises it in the state of crystalline needles.

Tellurious acid (TeO_2) fuses also into a yellowish liquid, but is more difficult to volatilise, and the sublimate is not crystalline, nor in needles.

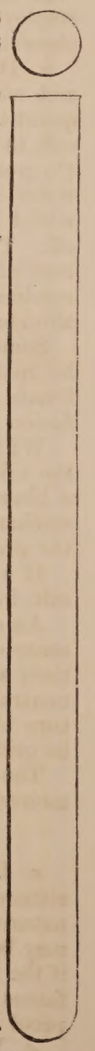
Osmic acid (OsO_4) is softened by the heat of the hand; when heat is applied it fuses, and a further increase of heat volatilises it into white crystalline needles, or small white drops—but the fumes are pungent, and provoke coughing, whilst their odour resembles that of chloride of sulphur.

t. If the sublimate is *white*, the operator, instead of triturating a *fresh portion* of the substance with solution of KO, as directed in this column, may pour a little aqueous solution of potash into the tube, and shake it so as to bring it in contact with the sublimate, when an odour of NH_3 will be evolved if an ammoniacal salt be present.

Most salts of ammonia are decomposed by heat, in which case, an odour of ammonia is evolved, or may be detected by the blue reaction on red litmus paper previously moistened. Those, however, which resist decomposition always yield a white sublimate, from which an evolution of ammonia is obtained by treatment with solution of potash.

The salts of ammonia which contain a fixed acid, sublime only partially. A ready way of placing the presence of ammonia beyond doubt, consists in mixing them well with a little carbonate of soda and a little water, so as to form a small mass, which, being then gently heated upon a strip of platinum foil, immediately evolves the characteristic odour of ammonia.

u. When HgCl is to be tested in the manner alluded to in Col. 17, the experiment is sometimes attended with considerable difficulty, unless certain precautions are taken, one of them, without which the experiment will fail, is to mix intimately the substance with the carbonate of soda. For this purpose, the mixture should be thoroughly triturated, and then slightly moistened before putting it into the tube, which had better not be more than $\frac{2}{8}$ or $\frac{3}{8}$ of an inch bore, as represented in the figure in the margin, drawn of the real size. Ordinary test-tubes are too large for the purpose, and they generally crack, or fuse before the experiment is completed. The heat must be continued until the mixture in the tube has completely fused, wherefore, the flame of the spirit-lamp must be urged by the blow-pipe. The heat of the spirit-lamp alone is quite insufficient for the purpose. The volatilised mercury condenses on the cold sides of the tube, in the shape of a greyish coating, mixed with a scanty yellow sublimate. In order to render the globules apparent, the operator should rub the sides of the glass, where the coating has condensed, with a wet glass rod, or with the extremity of a wet piece of stiff paper, or card-board. The fine particles of mercury agglomerate, and may then be distinctly perceived, though very careful observation is often necessary, and the eye may require the aid of a magnifying glass. With Hg_2Cl the experiment presents no difficulty whatever, and may be performed in any glass test-tube. (See also, Observations *x*, col. 18.)



v. Selenium, when present in somewhat large quantity, produces a black sublimate, which, by trituration, becomes red, but, if in small quantity, it forms a sublimate of a reddish colour. It may easily be confounded with sulphur, for, like the latter element, it first softens, becomes viscid, and evaporates in the form of a gas of a yellow colour, though of a less deep hue than sulphur, and when inflamed in the air it burns with a blue flame, with, however, this essential and quite characteristic difference, that the odour, provided a red heat is employed, is that of decayed raddish.

x. All the salts of mercury are volatilised and decomposed by heat alone, and most generally yield thus globules of metallic mercury. The two chlorides of mercury, however (Hg_2Cl and HgCl), and sulphuret of mercury (HgS) form an exception; they are volatilised but not decomposed by heat. Fusion with carbonate of soda (NaO,CO_2) readily effects their decomposition, provided the flame of the spirit-lamp is urged by the blow-pipe. If corrosive sublimate (HgCl) is present, the fusion of the substance with carbonate of soda (NaO,CO_2) before the blow-pipe in a glass-tube, will produce a greyish or blackish sublimate; both chlorides of mercury (Hg_2Cl and HgCl), and, in fact, all the salts of mercury when thus mixed with carbonate of soda (NaO,CO_2), and heated in a small test-tube by *means of the blow-pipe*, yield a sublimate, in which globules of mercury, if not readily apparent, can be rendered immediately so by rubbing the sides of the tube, where the grey or black coating has settled, with a glass rod, or even a strip of stiff paper. The small particles of mercury being thus agglomerated, at once run into larger globules of metallic mercury. It is absolutely necessary to heat the tube containing the mixture with the blow-pipe, the flame of the spirit-lamp alone being altogether incapable of effecting the decomposition of the mercurial compound. It is also advisable to moisten the mixture slightly before heating it, otherwise, the salt of mercury might be altogether, or partly, volatilised without decomposition, which is the case more especially with the two chlorides, bromides, and iodides of mercury (Hg_2Cl and HgCl—Hg_2Br and HgBr—Hg_2I and HgI). The quantity of carbonate of soda (NaO,CO_2) used should be about double that of the substance.

y. Realgar, or bisulphuret of arsenic (AsS_2), has a fine orange red, or brownish red, colour, and, like the trisulphuret of arsenic (orpiment AsS_3) and the penta-sulphuret of arsenic (AsS_5) may be looked upon as a sulphacid, since it unites readily with alkaline sulphurets to form what are called sulphosalts. If a concentrated solution of potash be poured upon it it is decomposed into a hexabasic sulphuret of arsenic (AS_6S) of a brownish black colour, insoluble in water, and into a soluble combination of bisulphuret of arsenic and of sulphuret of potassium. (Bisulphoarseniuret of potassium, $KS+AsS_2$.)

z. Selenium (Se) when present in somewhat large quantity, produces a black sublimate; but if in small proportion, the precipitate is reddish, in either case, trituration, or rubbing with a glass rod, produces a deep red powder. The presence of selenium may always be detected by the very characteristic odour of its fumes, namely, an odour of decayed cabbage or horse-raddish.

TABLE I.—B.

Preliminary TESTS and PROCESSES for ascertaining the probable CONSTITUENTS of COMPOUNDS to be analysed.

The substance is in the SOLID state, but is NOT A METAL, NOR an ALLOY.

Put a small portion of the substance, well pulverized, and previously agglomerated with a little saliva, into a cavity scooped out in a piece of charcoal, and expose it therein to the inner or blue flame (reducing or de-oxydizing flame,) of the blow-pipe
After having examined the compound, according to this Table, the operator should go to Table I.—C.

The Substance is VOLATILIZED PARTLY or COMPLETELY. Sometimes with Incrustation

Presence of (Observations c, Col. 5, 6.)

NH_3,	S,	Ca,
Hg,	I,	Te.
As,	Se,	Benzoic acid.
Cy,	Sb,	Tartaric acid.
Zn, &c.,	&c., &c.,	Observations a.

These substances have been alluded to in the preceding table. See col. 2, 10, 11, 12, 13. of TABLE I.—A.

If a residue or incrustation is left, treat the substance as from 7 to 17.

If the substance *fuses* previously to volatilizing, and leaves on the charcoal a very easily volatilizable incrustation of a

White Colour.

Presence of Sb, Te.

Put a portion of the substance in the elbow of a tube, open at both ends, and heat it therein with the blow-pipe.

1	2
White Sublimate	White Sublimate
which being slightly heated fuses into transparent drops before volatilizing. Te. Observat. b.	which being slightly heated volatilizes, but does not fuse into drops. Sb. Confim by fusing in the inner flame with NaO,CO_2, + KCy— A brittle metallic bead.

ODOUR of GARLIC or NO ODOUR.

Whether or not an odour is evolved, mix a small portion of the substance with NaO, CO_2, in powder, and expose the mixture to the reducing or inner flame of the blow-pipe.

3
GARLIC Odour
Presence of As.

DEFLAGRATION.

Nitrates, Chlorates, Bromates, Iodates, Nitrites, Perchlorates, Permanganates, Selenites, Selenites. Observ. q.

See Col. 5, and those following for the base.

See also TABLE I. – E.

4

The substance is ABSORBED by the Charcoal.

(Observations c.)
Presence of Salts of
K,
Na,
Moisten a portion of the pulverized substance with saliva, and heat it before the blow-pipe on a loop of platinum wire. (Observations d.)

Faint Purple Flame.

Presence of K

Yellow or Reddish Yellow.

Presence of K Na

The salts which present this reaction in the most characteristic manner are, the

Nitrates,
Chlorides,
Carbonates,

Of these alkalies.

5	6
The smallest quantity of Na is sufficient to obliterate this re-action, for, in that case, the flame is *yellow*, even though much K may be present.	Even though much K may be present the flame is *yellow*, the reaction of the Na being much the stronger of the two.

A WHITE RESIDUE is left, but NO METALLIC BEAD, With or without previous watery fusion. Observation e. (See Col. 2, TABLE I.—A.)

Presence of

BaO	StO	These four become very luminous when heated before the blow-pipe. (Obser. f.)
Al_2O_3	MgO	
SiO_3	CaO	
	ZnO	

Moisten a portion of the residue with a drop of CoO,NO_5, and placing it on the hook of a platinum wire, heat it strongly thereon before the blow-pipe. The mass, after cooling, is of a

Fine Blue Colour.

Presence of Al_2O_3 and possibly SiO_3

The blue colour produced by Al_2O_3, is much more intense.

Treat a fresh portion of the residue before the blow-pipe with microcosmic salt upon the hook of a platinum wire.

7	8
Fuses into a clear bead.	Insoluble.
Al_2O_3	SiO_3 The silica is seen floating in the bead.

Light Pink.

Presence of MgO

The colour is so faint that it is often overlooked, and moreover, it takes place only when perfectly pure, the smallest trace of metallic oxyde interfering, and altogether preventing its production.

The colour cannot be well observed, except after the mass has entirely cooled, and a strong blast is necessary to develope it.

9

Intense and fine Green Colour.

Presence of ZnO

This substance has been alluded to. See TABLE I. A. Col. 24.

Also this Table, Col. 13.

10

O (Observations) g.

Presence of BaO StO CaO

StO, and especially CaO, become very luminous when strongly heated, which is not the case with BaO.

Possibly, YO Gl_2O_3 Zr_2O_3 may also be present.

Go to TABLE I. C. and D.

Obser. q.

11

A WHITE RESIDUE Generally accompanied by a METALLIC BEAD, With or without incrustation.

Take a portion of the substance, mix it with NaO,CO_2, and having moistened it with a little saliva to make it cohere, heat a little of the mass upon charcoal, *before the reducing* or inner flame of the blow-pipe. (Observation h.)

NO INCRUSTATION on the charcoal but a METALLIC BEAD is produced after strong blowing.

Presence of
Au.
Ag.
Sn.
Cu.

If no metallic bead. (Obs. i, n.

If the metallic bead separated from the scories is

White

And if being heated in the oxidizing or outer flame of the blow pipe it becomes covered with a

White non-volatile.

Coating. Sn. Obser. j. (See also Col. 21.) But above all, see the observs. on this column.

12

An INCRUSTATION takes place on the charcoal WITH or WITHOUT Production of a METALLIC BEAD.

Presence of

Zn	No metallic bead. *Yellow* incrustation becoming white after cooling.
Sb	Often a brittle metallic bead is produced; white and very volatile incrustation.
Pb	Metallic bead always obtained; soft, malleable; reddish yellow incrustation. (Observ. k.)
Bi	Ditto, brittle; orange yellow incrustation.
Cd	No metallic bead (Observation l); brown incrustation.

If therefore, the colour of the incrustation on the charcoal is more or less.

White when Cold.		Yellow.	or	Brown.
Zn.	or Sb.	Pb.	Bi.	Cd.
If the incrustation when hot was	If the metallic bead emits, for some time, thick white fumes which on cooling become full of spicular crystals of Sb_2O_3, or if no metallic bead being obtained, the incrustation is white and very easily volatilized Sb. See Col. 1, 2.	If the bead obtained is greyish white, soft and malleable, the incrustation being	If the bead is white, very fusible, but BRITTLE, the incrustation being	If no bead is obtained but a brown smoke, and a brown incrustation
Yellow.		**Yellowish Red.**	**Orange.**	**Brown.**
and became		Pb.	Bi.	Cd.
White again		See Observation k.	Confirm by dissolving the bead, and apply tests for Bi. (See Dictionary.	Observ. l.
on cooling Zn See Col. 10 also TABLE I. A. Col. 24.				

13	14	15	16	17

The RESIDUE is NOT WHITE but has ANOTHER COLOUR.

NO INCRUSTATION, NOR METALLIC BEAD. (Observation m.)

But a mass which sometimes is black, greyish, and sometimes perfectly white. If perfectly white and strongly luminous when heated in a good blast, and in the inner flame, StO—CaO—MgO, or ZnO may be present, although a white residue may not have been left on the charcoal. (Group 7 to 11.)

Presence of Pt – Fe—Ni—Co – Mn—Cr—As—(Odour of Garlic). Cu frequently yields no metallic bead, but sinks in the charcoal. See Observations i, on Cu, Col. 12. Other substances of more rare occurrence may also be present. (See Observation j.)

Treat a very minute portion of the pulverized compound with borax on the hook of a platinum wire in the *reducing* flame of the blow-pipe. If it produces a bead which is

Blue.	Pale Bottle Green.	Grey.	O.	O.	Fine Emerald Green.
Co. and possibly Cu. See Observation n.	Fe. See Observation n. Apply the other tests. (See Dictionary for confirmation.)	Ni	Pt. Sn. In the oxydizing flame. **O.** Mix a portion of the substance with one part of NaO, CO_2, and two of KCy, heat upon charcoal in the *reducing* flame of blow-pipe. Metallic bead, white, readily oxydizable. Sn.	Observation o, nothing in *the reducing flame*, but in the oxydizing flame **Amthyst.** Fused with NaO, CO_2, on the hook of a platinum wire and in the oxydizing flame **Turquoy Blue.** Mn.	Cr. Fused with NaO, CO_2, before the blow-pipe upon platinum foil or hook, an opaque, greenish yellow glass bead is obtained which is $Na\,O, Cr\,O_3$ **Yellow.** Cr. Observation p.
18	19	20	21	22	23	24

Grey, infusible powder becomes metallic by rubbing in agate mortar. Pt

There is an INCRUSTATION but NO METALLIC BEAD.

OBSERVATIONS ON TABLE I.—B.

Group 1 *to* 4.

a. Among the substances which appear in this group, several leave an incrustation or coating on the charcoal support. The Oxydes of Antimony yield a white coating, and if it is in sufficient quantity, a brittle metallic bead.

TeO_2 leaves a white incrustation, and imparts a blue colour to the flame of the blow-pipe.
Zn a yellow coating, which, after cooling, is white.
Cd a brown coating, the colour of which is best observed after cooling.

b. Chloride of Lead (PbCl), when roasted in a tube, open at both ends, volatilises very much like *Tellurious acid* (TeO_2), and fuses like it into drops, emitting thick fumes, *but it leaves a* YELLOW *residue* of basic chloride of lead (Pb_2Cl), and moreover, the incrustation on charcoal is yellow, or yellowish red, which is quite sufficient to distinguish it from either Tellurium or Antimony. When the compound is a combination of *Tellurious acid* (TeO_2) with *lead*, a white sublimate of Tellurious acid (TeO_2) is formed at some distance, but another yellowish red sublimate, nearer the substance under examination, is also produced, which is Tellurite of Lead, and which, as it cannot be fused into drops, might be mistaken for Antimonious acid (Sb_2O_4).

Group 5 *to* 6.

c. Beginners may find some difficulty in determining whether the substance has volatilised as in Col. 1 to 4, or has been absorbed by the charcoal, as in Col. 5 to 6. If volatilisation has taken place, fumes, more or less thick, will have been observed.

d. The substance tested for potash before the blow-pipe, should be held so that the point of the blue, or reducing flame, touches the mass, the exterior flame becomes then tinged with a faint violet colour, if it contains potash, *provided no soda is present.*

All the salts of potash, however, even though they be in a pure state, do not exhibit this violet flame, at least in a perceptible degree; thus, whilst the Nitrate, chloride and carbonate of potash present this reaction in a distinct manner, it is so exceedingly faint in the *borate*, and in the *phosphate* of that base that practically it may be said not to exist.

The *yellow* flame of soda, on the contrary, is always so strong, that the smallest quantity of a salt of that base completely obliterates the violet flame of potash, although the latter base may be present even in considerable quantity. Yet the operator must bear in mind that *platinum* wire itself imparts a *yellow* colour to the flame of the blow-pipe, especially if the wire has been handled with moist hands. This effect appears to be due to the presence of the chloride of sodium contained in the moisture which issues from the skin.

Group 7 *to* 11.

e. By the white residue left on the charcoal is meant a white earthy looking residue, *not a glass*, since oxyde of cobalt (and consequently the nitrate of cobalt employed) imparts a blue colour to glasses.

f. Glucina, Yttria and Zirconia become also very luminous when heated.

g. The indication O, put in that column as the result of the fusion of the substance with CoO,NO_5 on the hook of a platinum wire, does not mean that a colourless mass is obtained, but merely that the mass is neither blue, nor light pink, nor green.

Columns 12 *to* 24.

h. The fusion of the substance with carbonate of soda (NaO,CO_2) frequently produces a globule, which is not metallic, but which an inexperienced operator may mistake for a metallic bead; such is the case more particularly with *sulphurets*, *seleniurets*, and *arseniurets*. Wherefore the substance should be roasted before fusion with carbonate of soda, if it be one of these substances. The roasting is easily effected in the oxydising flame, the mass being placed upon a piece of charcoal, or better still upon a piece of brick, or a small clay crucible. The heat applied at first should be very gentle, otherwise the mass, especially if it be a sulphuret or an arseniuret, would fuse, and the oxydisation would proceed but indifferently and slowly; should such a case happen, it is better to repulverise the mass, or to take a fresh portion of it. Towards the end of the roasting a stronger heat may be applied. Sometimes by fusion of the compound with NaO,CO_2 upon charcoal, a bead is obtained, but which is not metallic.

If the non-metallic bead so obtained is perfectly clear and limpid, the fusion being attended with effervescence, it is silicic acid. Titanic acid fuses also with NaO,CO_2, but the bead instead of being clear and colourless, is opaque or greyish. If, however, the silicic acid is combined with a base, as is the case with silicates, the bead instead of being clear, is sometimes coloured by the metallic oxyde of the silicate.

The following native silicates fuse with soda into a limpid glass. (See my edition of "Rose's Practical Treatise of Chemical Analysis," page 611) :—

Combinations of	Combinations of
QUARTZ, or rock crystal (pure silica), with a trace of metallic oxyde.	ALBITE, (silica, alumina, and soda.)
FELDSPAR, (potash, soda, silica, and alumina.)	PETALITE, (silica, alumina, lithia, and sometimes soda.)
LEUCITE, or AMPHIGENE, (potash, silica, and alumina.)	SPODUMEN, (silica, alumina, and lithia.)
LABRADORITE, (silica, alumina, lime, soda, oxyde of iron.	EMERALD, or BERYL, (silica, alumina, glucina.)
MEIONITE, or SCAPOLITE, (silica, alumina, lime, and soda.)	ZEOLITES, in general, (silica, soda, alumina, water.)
ANORTHITE, (silica, alumina, lime, and magnesia.)	REFRACTORY CLAYS.

The following fuse also with NaO,CO_2, but are generally coloured by the metallic oxyde of the compound :—

Combinations of	Combinations of
DIOPTASE, (silicate of copper and water.)	AXINITE, (silica, alumina, lime, protoxyde of iron and of manganese.)
ACHMITE, (silica, peroxyde of iron, soda.)	GARNET,, several species, (silicate of protoxyde of iron and of alumina.)
LIEVRITE, or YENITE, (Protoxyde of iron, silica, and lime)	IDOCRASE, (silicate of alumina and lime, with protoxyde of iron and of manganese.)
HELVINE, (silica, glucina, alumina, and peroxyde of iron and of manganese.	

Group 12.

i. The salts of *Copper*, treated before the blow-pipe with carbonate of soda, instead of a metallic bead very often yield only very fine metallic spangles, which sink into the pores of the charcoal, or are imprisoned in the fused mass of NaO,CO_2. In order to obtain the metal, the fused mass, and the surface of the charcoal being scraped off, should be pulverised and well triturated in an agate mortar with water, and the charcoal powder being washed away by decantation, the spangles of copper will be found at the bottom of the mortar. It is often sufficient to triturate the fused mass alone with water in an agate mortar to obtain the spangles of copper. See Observation n, Col. 18.

Whether the reduced metal is Au — Ag — Sn or Cu, may at once be recognised by treating it with nitric acid. If a white insoluble mass or powder remains, it is probably Sn, which may be further examined with the appropriate tests. If a yellow insoluble metal be left, immediately soluble in aqua regia, it is probably gold, which may be identified by testing for that metal. If, on the contrary, the Nitric acid employed dissolves the reduced metal, then divide the solution into two portions; to one of these portions add a few drops of HCl. If a white curdy precipitate is produced, immediately soluble in NH_3, re-precipitated by NO_5, it is *silver*. To the other portion add NH_3; if a blue colour be produced, and if on supersaturating the ammoniacal solution with Acetic acid, the further addition of K_2Cfy, produces a crimson precipitate, the presence of *Copper* is certain.

j. It very frequently happens that *salts of Tin* do not yield a metallic bead when so treated, either on charcoal alone, or on charcoal with carbonate of soda, wherefore the operator must go to another group of columns, and test according to Col. 21, with one part of carbonate of soda and two parts of cyanide of potassium in the inner or reducing flame of the blow-pipe, and on a charcoal support. Take care that a sufficient quantity of flux is used.

Whether or not a metallic bead has been produced by treatment with NaO,CO_2 before the blow-pipe, with or without incrustation, do not omit to submit the compound to the tests described in Cols. 13 to 17 and 18 to 24, for suppose the compound to contain, for example, silver and cobalt, it is clear that the silver will be obtained by the test in Col. 12, but the operator must go to Col. 18 for the cobalt.

In addition to the metals or oxydes, and combinations of oxydes, reduced by NaO,CO_2 upon a charcoal support in the interior flame of the blow-pipe, the following compounds may be added, namely, Molybdic acid (MoO_3), Tungstic acid (WO_3), which will be taken account of in TABLE XXIX., and following.

Group 13 *to* 17.

k. If the substance which has yielded a globule of metallic lead is *chloride of lead*, it will have fused when heated in the test tube closed at one end, as already mentioned in Col. 1, and if it be a *tellurite of lead*, a white incrustation of tellurious acid, easily volatilisable, will be left on the charcoal, but another incrustation of a reddish-yellow colour, will at the same time be produced on the charcoal, nearer the substance under examination, which incrustation is tellurite of lead. (See Obs. *a*, *b*, Col. 1 to 4,of this Table.)

l. Cadmium is so volatile that the first impression of the heat volatilises it in the form of brownish fumes, and an incrustation of the same colour is left all round the place where the assay was put on the charcoal, *no metallic bead being produced.* But it is evident that if Cadmium exists, mixed or alloyed with lead or bismuth, &c., a metallic bead and an incrustation will be produced, the bead being due to the lead, bismuth, &c., and the incrustation to all these metals and to Cadmium. Nay, if the assay was a metallic-looking mass, such as, for example, an alloy of lead, tin, bismuth, &c., it may happen that the Cadmium not having completely volatilised, the bead obtained will still retain more or less Cadmium, The operator would not, therefore, be justified in concluding, from the production of a metallic bead, that Cadmium is absent. It is clear, in effect, that if the mass consists of or contains Cadmium or Tin, alloyed or mixed with lead or bismuth, a metallic bead and an incrustation will be obtained.

Group 18 *to* 24.

m. The substances which are not attacked by NaO,CO_2 upon charcoal are Alumina, Magnesia, Lime, Strontia, Baryta, and the Alkalies, and the more rare bodies Uranium, Tantalic acid, Zirconia, Thorina, Yttria, Glucina, which will be taken into account in TABLE XXIX., and following.

n. The operator must bear in mind that, for as much as Copper gives no incrustation, and very often does not yield a *metallic bead, but is reduced into fine metallic spangles, which sink into the charcoal*, it may have been overlooked in Col. 12. But the omission will now be discovered when fusing with borax, for if copper be present in somewhat large proportion, fusion in the *oxydising flame* will produce a green or bluish green glass, which might be mistaken for Co or Fe, but for that circumstance, that the smallest particle of Co imparts an intense blue colour to the bead, and Fe gives a much less clear, and decided coloured glass than Cu. Under all circumstances, if a bluish-green, or green glass be obtained, Cu should be looked for. (See Ob. *i*, Col. 12, Copper.) In the oxydising flame, the bead produced by copper with borax is green when hot, but it becomes pale-blue on cooling. In the reducing flame, however, the bead is brownish red.

o. Manganese treated with borax in the reducing flame of the blow-pipe, gives a colourless bead, but it generally happens that an amethyst colour is produced, either from the operator using a larger quantity than can be well enveloped by the blue flame, or because he does not keep it steadily in that flame, but allows it to become oxydised. The amethyst colour, however, is quite characteristic.

p. When any substance containing chromium, in any state, is *fused* with nitrate of potash alone, or mixed with carbonate of soda, and the fused mass is digested in hot water, a yellow solution is obtained, which becomes deep orange by supersaturation with an acid, and is precipitated yellow by the salts of barium and of lead.

q. Before going to another Table, always examine whether any of the other effects mentioned in the present one are produced.

TABLE I.—C.

Preliminary TESTS and PROCESSES for ascertaining the probable ACIDS (inorganic and organic) contained in the Compound to be analysed.

The Compound is in the SOLID state, or is made so by evaporation to dryness in a capsule, by means of a Steam Bath. (Observation *a*.)

Reduce the Compound to fine powder, put a portion of the powder into a perfectly dry glass test-tube, pour some concentrated SO_3, HO, and if, in the course of a short time, no action has taken place, or after all action in the cold has subsided, apply heat.

NO ACTION,
Or the Compound merely dissolves without effervescence.

SO_3—PhO_5—PhO_3—PhO--BO_3 (except Fluorine is present)--SiO_3 (except Fluorine is present)—SeO_3 —SeO_2 —AsO_5 —AsO_3—AsS—SbO_5 —IO_5.

Take another small portion of the powder, fuse with Na O, CO_2 on a charcoal support, remove the mass (or the charcoal where the mass was, if it have sunk in it), place it upon a clean piece of silver, and moisten with dilute HCl.

Brown Stain.

Odour of HS.

Presence of a sulphate. (Observation *b*.)

SO_3

The presence of AsO_5 AsO_3 will have been detected in TABLE I.—A. Col. 14, and in TABLE I.—B. Col. 3. They will besides be identified in the systematic analysis of the compound by HS, &c.

AsS AsO_5 AsO_3

The presence of IO_5, and of Iodates will have been detected in TABLE I.—A. Col. 6.

IO_5

Place at the bottom of a test-tube a small bit of K, or Na, and over that put a small quantity of the pulverized compound, *well dried;* heat the whole cautiously to redness, add a little Hg to amalgamate the excess of K employed, and pour it out again. Breathe now on the mass in the tube with the mouth, by means of a smaller tube,

Odour of Garlic.

The methods of distinguishing between PhO_5—PhO_3—PhO will be given in the TABLES for the Systemat. Analysis of Compounds.

PhO_5 PhO_3 PhO.

Mix another portion of the powder with concentrated SO_3 HO, add naptha (pyroxylic spirit), and inflame the mixture.

Beautiful Greenish Yellow Flame.

Borates.

Pulverize a portion of the compound with CaFl, add concentrated SO_3HO, and heat gently. Introduce into the fumes, but without touching the mass, a piece of paper.

Turns Brown.

BO_3

(Observation *c*.)

BO_3

Reduce another portion of the compound to very fine powder, mix it with five or six times its weight of NaO, CO_2, fuse the whole by a strong heat of blow-pipe, in thin platinum capsule; after cooling, pour into the capsule some water and a little HCl. Boil.

Gelatinous Mass.

SiO_3 Silicates.

Pulverize another portion of the compound with CaFl, add conc. SO_3, heat gently, and lead the fumes evolved through water.

White Gelatinous Mass.

SiO_3. See Observation *c*.

SiO_3

Heat another portion of the compound in a tube open at both ends.

Red Powder.

Se.

See besides TABLE I.—A, Col. 20, 23. (Observation *d*).

Mix another portion of the compound with sal-ammoniac and heat the whole in a small retort.

Black,

or Dark Grey Sublimate.

In the neck of the retort, which by trituration becomes

Red.

Se.

(Observation *e*.)

SeO_2 SeO_3

The presence of SbO_5 will already have been detected in TABLE I.—B. Col. 2. 14.

SbO_5

EFFERVESCENCE, Colourless Fumes or Gases, but NO CHARRING.
(Observation *a*.) If Fumes are not readily apparent, they may be rendered so, by introducing a glass rod, moistened with NH_4 O.

CO_2–$\bar{O}$,HO--$\bar{F}$oHO--CrO_3–HS--SO_2–S_2O_2–Metallic Sulphurets--NO_5–HFl--HCl--$\bar{A}$, HO--HCy--H_2Cfy --HCyS$_2$–(Some Sulphurets disengage SO_2, others disengage HS, when treated by concentr. SO_3HO.

INODOROUS, or nearly so.

Take another portion of the compound, put it into a test-tube, and pour upon it some HCl diluted with five or six times the bulk of water, adapt perforated cork with bent tube, plunging in lime-water, covered with olive oil; and apply heat, if necessary, (The apparatus is represented, Obser. *g*. TAB. I.—E.)

White

CO_2.

(Observation *h*.)

CO_2

Hold a lighted match at the mouth of the tube in a somewhat dark place, if the gas evolv'd

Burns with Blue Flame

$\bar{O}$, HO

$\bar{F}$o, HO

HCy.

If there be any doubt as to the blue flame, operate as described in the tests for Oxalic Acid. (See Dictionary).

The presence of these three acids is identified as described in TABLE XXI. Col. 5, 16, 17. TABLE XXII. B. Col. 2. (Observation *i*.)

$\bar{O}$, HO

$\bar{F}$o, HO

HCy.

Rekindles a red-hot splinter of wood

$Cr O_3$

The residue in the tube is generally

Green,

(unless obliterated by other colours), and contains $Cr_2 O_3$, SO_3, the presence of Cr may be detected therein by the blow-pipe, as described in TABLE I.—B. Col. 24. (Observation *j*.)

CrO_3

Odour of HS.

Certain presence of Alkaline, or of earthy sulphurets. (Observation *k*.) See also the observation *m* on Col. 13, second §

Hold at the mouth of the tube a piece of paper moist with basic acetate of lead $(3PbO)\bar{A}$

Black.

Heat another portion of compound in a tube open at both ends.

Odour of SO_2

Sulphurets.

HS

ODOUR of SO_2. (Observation *l*.)

SO_2 — S_2 O_2, or sulphites & hyposulphites, or metallic sulphurets. (Observations *k*,*l*,*m*,*n*.)

Treat a portion of the compound with water, filter, and to the concentrated filtrate add HCl.

Odour of SO_2.

NO Milkiness.

The gas bleaches brazil wood paper. Causes a *white* deposit of sulph. in HS water. Pour a portion of the solution, to which no HCl has been added, into an alcoholic solution of Iodine.

Decolorized. Obs. *m*.

Sulphite.

SO_2

Milkiness, or Yellow ppte.

The gas bleaches brazil wood paper. Causes a white deposit of sulph. in HS water. Pour a portion of the solution in which no HCl has been added into an alcoholic solution of Iodine.

Decolorized.

Hyposulphite

(Observation *n*.)

S_2 O_2

Heat another portion of the compd. with NO_5.

Ruddy Fumes.

Sulphuret of metal. (Observation *o*.)

Boil the mass with NO_5, if necessary, to syrupy consistence

Yellow lumps of Sulphur.

Sulphuret of metal.

S

SUFFOCATING Acid Odour.

In contact with moist air, the fumes are white. Presence of HCl or chlorides, HFl or fluorides.

Put a fresh portion of the pulverized compound into a platin. crucibl. pour concentrated SO_3 upon it; cover the whole with a waxed piece of glass, bearing writing traced with a point, as described in the tests for HFl. (See Dictionary.)

Corrosion.

HFl, or Fluorides.

HFl

Expose a portion of the pulverized compound with microcosmic salt, to the smallest possible flame of a spirit lamp, on the hook of a brass wire.

Blue Flame.

HCl. or chlorides, (Obser. *p*.) In presence of certain peroxydes, mentioned in TAB. I.—E. Col. 6. a yellowish gas (which is chlorine) is evolved. In presence of nitrates, chlorine and nitrous acid fumes are evolved. HCl.

ODOUR of NO_5.

If NO_5, that is if a nitrate is present it will already have been detected in TABLE I.—A. Col. 3.

NO_5

ODOUR of Vinegar.

$\bar{A}$, HO add alcohol and apply heat.

Odour of Acetic Ether.

Confirm by pulverizing a portion of the compound with about its own bulk of As O_3, transfer to a small test tube, add to the mass a small bit of caustic potash, and expose to the heat of a spirit lamp (caution)

(Observation *q*.)

Odour of Garlic.

$\bar{A}$, HO, or Acetates.

$\bar{A}$, HO

Odour of Bitter Almonds

HCy—H_2 Cfy HCyS$_2$ add an excess of SO_3, and boil. A gas is evolved which on being lighted burns with a

Blue Flame.

It is CO resulting from the decomposition of the cyanide, as described in Col. 10 These three acids or their compounds may be identified as described in the systematic analysis of single compounds TABLE VII. Col. 20, 25, 26. or of complex compounds. TABLE XXI. 12, 17,

HCy H_2 Cfy HCy S_2

Colourless Gas, but CHARRING, especially if heated.

All the acids which behave in that manner, are ORGANIC, and the boiling should be continued for some little time. The acids, which are considered here, are—

$\bar{T}$, 2HO —$\bar{C}$i, 3HO--$\bar{Q}$t, HO--$\bar{G}$, 2HO —$\bar{U}$, HO—$\bar{M}$, HO–

The gases evolved, consist of a mixture of CO + CO_2, with generally some SO_2.–$\bar{M}$, HO however evolves nothing else than SO_2.

All these acids will be identified in the systematic analysis of single compounds. TABLE VIII. TABLE XII. Or of complex compounds. TAB. XXI. &c. All the organic acids are decomposed by boiling with NaO, CO_2, and are thereby converted into alkaline salts, which are then soluble in water, and in the solution of which they may therefore be easily detected.

Tartrates may sometimes be at once detected by projecting a fresh portion of the compound upon ignited charcoal, when a characteristic odour of burnt sugar is evolved.

$\bar{T}$, 2 HO
$\bar{C}$i, 3 HO
$\bar{Q}$t, HO
$\bar{G}$, 2 HO
$\bar{U}$, HO
$\bar{M}$, HO

THICK WHITE FUMES, or WHITE SUBLIMATE.

BFl_3 – $SiFl_3$ – $\bar{B}$z, HO--$\bar{S}$, HO

Plunge a piece of paper in the glass tube among the fumes evolved but without touching the mass.

The Paper turns Brown

BFl_3.

See Observ. on Col. 5.

BFl_3

Close the test-tube with a cork provided with a bent tube moist with water.

Gelatinous coating of Silica along the tube.

$SiFl_3$. See Observ. on Col. 6.

$SiFl_3$

White fumes producing a white sublimate in crystalline flakes at the upper part of the tube, and which have an

Aromatic ODOUR of Benzoin.

$\bar{B}$z, HO

The distinguishing characters will be given in the systematic analysis of simple compounds. TABLE VIII. Col. 9, 10. TABLE XII. Col. 11 12. and in the analysis of complex compounds TABLE XXI. &c.

$\bar{B}$z, HO

White fumes condensing into crystalline needles accompanied by the evolution of an

IRRITATING Odour.

$\bar{S}$, HO

The distinguishing characters will be given in the systematic analysis of simple compounds TABLE VIII. Col. 9, 10. TABLE XII. Col. 11, 12, and in the analysis of complex compounds, TABLE XXI. &c.

$\bar{S}$, HO

RUDDY or BROWN FUMES. (Observ. *r*.)

NO_5, or Nitrates, if heat be applied; or if much SO_3 has been used; or if sulphurets or metallic copper are present at the same time;

$Br O_5$ and bromates; $Cr O_3$ in presence of chlorides, or bromides, HBr and bromides.

If a nitrate or a bromate is present, it will have been detected in TABLE I.—A. Col. 3, 5. Add however to the SO_3 HO in the tube, as much HO as will increase the bulk one-fourth or one-third (the water to be added drop by drop, by means of a pipette) and add copper shavings, nitrous acid fumes will be produced if a nitrate be present (Ob. *r*.) For the detection of a bromate or a bromide, see Obser. *s*.

HBr BrO_5 NO_5

If instead of ruddy, or of hyacinth-red, or brown fumes, a blood-red liquor condenses in the tube, the compound contains probably a chromate mixed with a bromide, or a chloride; take, therefore, another portion of the compound, well pulverized, & introduce it into a test-tube, provided with a tube fitted to a perforated cork, and plunging into a tube surrounded by water, thus:—

add, SO_3 HO, and heat gently.

Blood-red fumes or liquid distils

and falls to the bottom of the tube, or fumes only, Br, or $CrCl_3$, $2CrO_3$, add to the brown liquid, or vapours, an excess of NH_4 O.

Decolourized.

Br. add excess, HCl and ether. Shake, &c. as described in test for HBr Obsv. *t*.

Br.

Turns Yellow.

$Cr Cl_3$, $2Cr O_3$

$Cr O_3$ + HCl

Yellow, or Yellowish Gas.

(Care.) (Obs. *u*.) NO_5 in presence of chlorides, HCl in presence of certain peroxydes, ClO,—ClO_5 HO

Odour of Cl.

The gas bleaches litmus paper and sulphate of indigo

Treat the compound by water, filter and evaporate the filtrate to dryness at a very gentle heat. Transfer a portion of the mass to test tube, heat to fusion, and project a little paper within the tube

Deflagration.

ClO_5 which will have already been detected in TABLE I.—A. Col 4.

ClO_5

Violet Fumes

A dark grey metallic sublimate forms on the cool sides of the tube. Place a piece of paper moistened with starch paste at the mouth of the tube.

It turns

Blue.

HI

or an iodide.

HI

Group 1 *to* 8.

a. Generally, the evaporation to dryness, especially if there be much liquid, may be begun with an ordinary fire, or by means of a spirit or gas-lamp, or sand-bath; it is only when the liquor has become concentrated that the evaporation should be carried on to dryness by means of the water-bath, in order to prevent loss by spirting, or the volatilisation of certain substances. A stronger heat, however, than that of the water-bath may be altogether employed, if the operator has first ascertained that no substances likely to be thereby dissipated are present, and at any rate he should diligently stir the mass, and reduce the heat towards the end, in order to prevent projections. The flame of the lamp should always be so adjusted that the liquid is kept on the verge of simmering.

When, however, the operator is pressed for time, and if he have previously ascertained, or has reason to know that the compound under examination contains no substances capable of being lost by volatilisation, he may considerably expedite the evaporation to dryness by covering the capsule which contains the liquid, with a funnel somewhat smaller in diameter than the capsule, and having a large neck,—a funnel from which the neck has been altogether broken off is better than anything I know, for the purpose; the figure in the margin shows the arrangement. (See the note p. 2, *)

Col. 1.

b. Sulphurets behave like sulphates when fused upon charcoal with NaO,CO_2, but treatment with SO_3HO evolves either HS or SO_2. †

Col. 5.

c. If Fl be present with BO_3 or a borate, or with SiO_3 or a silicate, the addition of SO_3HO will evolve thick vapours of terfluoride of boron (BFl_3) or of silicium ($SiFl_3$). The presence of the first is detected, because a piece of paper plunged in the glass-tube, and among the fumes, but without touching the mass within it, becomes charred, terfluoride of boron being a gas which has such affinity for water that it actually produces it at the expense of the hydrogen of the paper.

Col. 6.

Terfluoride of silicium is recognised by the deposit of white gelatinous silica, which takes place if the gas evolved is made to pass through water, or if a moistened tube is adjusted by means of a perforated cork to the glass-tube into which the experiment is performed, in which case the disengagement tube immediately becomes coated with gelatinous silica.

Col. 7.

d. Take care not to confound this red powder with that produced by realgar (AsS_2) or orpiment (AsS_3). The odour evolved when the compound is heated on charcoal with NaO,CO_2 is sufficient to distinguish these two substances, selenium evolving an odour of rotten cabbage; arsenic, one of garlic.

The acid and the neutral seleniates are soluble in water, yet those of baryta, strontia, lime, and protoxyde of lead are insoluble, or very sparingly soluble in that menstruum.

The selenites of alkalies are soluble in water, and all selenites, except those of lead, and of silver, are soluble in acids, wherefore all acid selenites are soluble in water.

e. By means of sal-ammoniac, as directed in the table, SO_3 can be distinguished, and separated from SeO_3. In such a case the solution of the two acids should first be saturated by KO, evaporated to dryness, and the dry residue mixed with sal-ammoniac, and heated in a retort, will yield a sublimate of selenium.

f. If the effervescence or evolution of colourless gases be inodorous, CO_2 — $\overline{O}$,HO — $\overline{F}$oHO — HCy only are present; but if an odour be evolved at the same time, then the compound should always be tested first for the above-named acids, for they might of course be mixed with some of those other acids which disengage odorous gases when treated by SO_3HO.

g. The CO_2 evolved may be due also, as we just said, to the presence of an oxalate, *if heat has been applied*, for *SO_3HO does not decompose oxalates in the cold.* In that case, however, CO being produced at the same time, there can be no difficulty about detecting these salts. If the matter becomes charred, other substances are likewise present.

Group 9 *to* 20.—*Col.* 9.

h. It is necessary to use dilute HCl, and oftentimes heat must be applied, because several carbonates are not decomposed by undiluted and cold HCl; such is more especially the case with MgO,CO_2 — BaO,CO_2 — StO,CO_2 —PbO,CO_2, and even FeO,CO_2. Magnesian lime-stone (dolomite), which is a combination of neutral carbonate of magnesia and of carbonate of lime, produces only a very sluggish effervescence, unless heat is applied.

The layer of olive-oil is for the purpose of sheltering the lime-water from the CO_2 of the air.

Col. 10.

i. The formation of equal volumes of CO_2 and of CO, by the action of concentrated SO_3HO on oxalic acid and oxalates, is due to the great affinity of sulphuric acid for water. The action is represented in the following equation:—

$$\overbrace{C_2O_3HO}^{\text{Oxalic Acid.}} + SO_3,HO = CO + CO_2 + SO_3\,2HO.$$

The action of concentrated sulphuric acid on formic acid, and the formiates, is of an analogous character, the elements of water being taken up by the SO_3,HO, and a transposition of atoms takes place; thus:—

$$\overbrace{C_2HO_3,HO}^{\text{Formic Acid.}} + SO_3,HO = C_2O_2 + SO_3,3HO$$

Hydrocyanic acid, cyanides, and ferro-cyanides, when heated with concentrated SO_3,HO, yield also CO gas, which burns with a blue flame, because the elements of hydrocyanic acid arrange themselves with the elements of water in such a way as to form formic acid, and ammonia, which, when an excess of SO_3HO has been employed, become converted into CO and water, and the residue contains sulphate of ammonia, thus:—

$$\overbrace{H,C_2N}^{\text{Hydrocyanic Acid.}} + 4HO = \underbrace{NH_4OC_2HO_3}_{\text{Formiate of Ammonia.}}$$

$$\overbrace{NH_4OC_2HO_3}^{\text{Formiate of Ammonia.}} + SO_3HO = NH_4O,SO_3 + C_2O_2 + 2HO$$

Col. 11.

j. Chromates, when treated with SO_3HO, evolve oxygen, and, consequently, a splinter of wood retaining a red-hot point is rekindled by immersion into the gas evolved, as just said in the table; but this *alone* is not a characteristic sign, since *bromates*, submitted to the same treatment, evolve oxygen also, and consequently rekindle a splinter under the same circumstances; bromates, however, evolve, along with oxygen, hyacinth red fumes of bromine. If the chromate was in sufficient quantity, the residue or liquor in the tube is always green.

*Col.*12.

k. The sulphurets of the metals of the alkalies, and of the alkaline earths, are the only ones which evolve HS, when treated by concentrated SO_3,HO; others, such as sulphurets of iron, of manganese, of zinc, &c., do so only after an addition of water; whilst those of copper, mercury, silver, &c., when so treated, disengage a mixture of HS, and of SO_2, accompanied by a deposit of sulphur.

Col. 13 *to* 15.

l. The odour of SO_2 is often simulated by the fumes of HFl, which are pungent and suffocating; the operator will, therefore, do well not to rest satisfied with the mere odour evolved as evidence of the presence of these substances.

An odour of SO_2 may also be evolved by treatment with SO_3,HO, although neither sulphites, hyposulphites, hyposulphates, or sulphurets, are present. This is the case when the compound contains an organic matter, whereby the SO_3HO employed is deoxydised. But the presence of an organic matter will already have been detected in Table I.—A.

m. When sulphites exist in a compound with substances which easily part with their oxygen, on being treated by concentrated SO_3,HO, such as nitrates, chlorates, bromates, iodates, &c., it always happens, (provided such substances are sufficiently abundant), that no odour of SO_2 can be detected, because, in reality, no sulphurous acid makes its escape.

In the same manner, if the compound under examination contains a sulphite mixed with a sulphuret, it may happen that the HS evolved from the latter may destroy all the SO_2 evolved at the same time, in which case no odour of SO_2 can, of course, be detected, for

$$2HS + SO_2 = 2HO + S.$$

In such cases, therefore, unless either the sulphite or the sulphuret predominates, neither the one nor the other can be detected by the odour of the gas evolved, since the decomposition is mutual.

Again, any substance, or mixture of substances, capable of evolving chlorine when treated by concentrated SO_3,HO, will destroy any sulphuretted hydrogen which may be given up at the same time, for

$$Cl + HS = HCl + S.$$

These remarks apply to bromine and iodine, thus:—

$$I + HS = HI + S.$$
$$Br + HS = HBr + S.$$

It is, therefore, only when alone, or when mixed with carbonates, oxalates, metallic chlorides, or fluorides, or with salts of fixed acids, that sulphites, on being decomposed by SO_3,HO, can be recognised by the odour of the gas evolved, unless they greatly predominate.‡

Col. 14.

n. The above observations apply equally well to hyposulphites when existing in a compound in conjunction with the soluble sulphurets of the metals of the earths, or alkalies, for the odour of SO_2 and of HS may respectively overcome or neutralize each other. In that case it is best to take a portion of the pulverized compound, to treat it with water, and to add an excess of a neutral salt of zinc, the zinc of which is precipitated in the state of sulphuret, and, of course, in proportion to the amount of alkaline sulphuret present; whilst the excess of the salt of zinc employed, and all the hyposulphite of the compound, remain in solution. By filtering, and adding HCl to the filtrate, a milkiness, or precipitate of sulphur, accompanied by an odour of SO_2, will take place, which are among the distinctive characters of hyposulphites.

A yellow precipitate, produced by the addition of HCl to the liquor, does not, however, necessarily imply the presence of a hyposulphite; for example, AsS_3, when prepared in the wet way, that is, when obtained by passing a stream of HS in a solution of AsO_3, is slightly soluble in water, from which it is immediately precipitated in yellow flakes by HCl. Before concluding to the presence of a hyposulphite, the other characters must be rendered manifest.

Col. 15.

o. When a sulphite is boiled with NO_5, ruddy fumes of nitrous acid are evolved also, but there is no deposit of sulphur, as is generally the case with the sulphurets in question. On the other hand, hyposulphites when so treated, evolve nitrous acid fumes, and yield a deposit of sulphur. But *all hyposulphites are soluble in water*, which is not the case with the sulphurets under present consideration.

Cinnabar (sulphuret of mercury HgS) is almost the only metallic sulphuret which is not attacked by NO_5, but the presence of that body will have been already detected in Table I.—A, col. 18.

Ruddy fumes are also produced when hyposulphates are heated with NO_5, the hyposulphate becoming converted into a sulphate, but hyposulphates are distinguished from hyposulphites because the latter, when decomposed by an acid, evolve SO_2, accompanied by a deposit of *sulphur*, which is not the case with either hyposulphates or sulphites; and, on the other hand, these two differ in this, that when hyposulphates in the solid state are heated in a glass test-tube, an odour of SO_2 is evolved, which is not the case with sulphites when similarly treated. In the wet way, solutions of hyposulphates when treated *in the cold* by HCl, do not exhale the odour of SO_2, whilst solutions of sulphites exhale that odour when so treated.

Read the observations on Col. 13—15.

Col. 17.

p. Bromides exhibit also the blue flame alluded to in this column, as one of the characteristic reactions of chlorides, except that the flame has a more greenish hue than is the case with chlorides. (See Tests for Acids, article HCl.)

Col. 19.

q. This odour of garlic is due to the formation of acetyle of arsenic, or cacodyle (C_4H_6As). The fumes are extremely poisonous; the operator is, therefore, cautioned against smelling the tube in which the reaction takes place. The tube should merely be passed rapidly under the nose. The odour is quite characteristic of the presence of acetates. §

Group 26, 28.

r. Ruddy fumes are not always produced in presence of nitrates by boiling even with a large excess of SO_3HO, but if water be carefully dropped into the tube, by means of a pipette, so as to dilute the acid therein about one-quarter of its bulk, and a few clean shavings of copper be then introduced, a powerful action immediately takes place, accompanied by ruddy fumes of nitrous acid.

All neutral nitrates are soluble in water; a few basic nitrates only are insoluble in that menstruum; wherefore the compound may at once be boiled with water, and filtered; the filtrate being evaporated to dryness, (towards the end, by steam heat), the dry residue may then be tested for NO_5 by the usual re-agents (see Dictionary) All nitrates, without exception, deflagrate when thrown upon ignited charcoal, or better still, when mixed with about their own weight of KCy, and thrown upon a red-hot platinum foil. The deflagration, in that case, is generally accompanied by a detonation.

s. If a bromate, or a bromide, and a nitrate be present, they may be readily distinguished as follows:— To the mixture of the pulverised compound with SO_3,HO, add carefully, by means of a pipette, as much water as will increase the whole about ten times its bulk. (The tube had better be put into a beaker containing cold water, in order to prevent its becoming hot). When cold, add ether, so as to form a layer about a quarter of an inch; shake the whole, and leave at rest for a few moments. If bromine be present, the ether floating at the top will be found tinged with brown or yellow, according to the quantity of bromine present. This coloured ethereal solution is immediately decolourised by a few drops of potash. (The mode of operation is described, Table VII., Cols. 22, 23.)

But whether nitrates be present or not, bromine can always be thus identified. Yet, a few metallic bromides resist the decomposing action of concentrated SO_3,HO.

Col. 27.

t. If, however, the compound contained a chromate and a metallic bromide contaminated by a little metallic chloride, the addition of NH_4,O, instead of completely decolourising the liquor, will leave it with a yellow tinge, due to the formation of a little chromate of ammonia, but then, if enough acid is added to supersaturate the ammonia, and ether be added as before, the bromine being thereby taken up, will again form a floating layer of a brown or yellow colour, which may be rendered more conclusive still by diluting pretty largely with water, which will attenuate the reddish colour of the solution of the chromate underneath, and leave the solution of bromine in ether unaltered.

Col. 29.

u. If a yellow, or greenish-yellow gas is evolved, accompanied by an odour of chlorine, the operator had better take care not to use too large a quantity of the compound, nor to pour upon the compound too large a quantity of SO_3,HO, and he must not apply heat, for if a chlorate be present, an explosion might then take place.

Except chlorate of potash, of soda, of ammonia, of baryta, of strontia, of lead, and of silver, all the other chlorates are deliquescent. All the chlorates are very soluble in water; chlorate of potash, which is less soluble than any other in that menstruum, does not require more than nine times its weight of water for its solution.

* *a.* But, considering that a compound may consist of substances which SO_3,HO attacks powerfully, and of substances on which it has little or no action, it is clear that by conducting the preliminary examination only as if an action had been produced by that acid, those substances which are not acted upon by it, and which may nevertheless be present at the same time, would escape detection. Wherefore, the operator should always treat the compound according to the directions given from Cols. 1 to 8, whether the substance has been attacked or not by treatment with SO_3,HO.

† *b.* Sulphurets, hyposulphates, sulphites, and hyposulphites, behave like sulphates when fused on charcoal with NaO, CO_2, but treatment with SO_3, HO will have distinguished them from each other in the Table. If the sulphate contained in the combination is one which gives no coloured glass with the fluxes, the fused mass will have a yellow or brownish colour, due to the fused sulphuret of sodium which is formed.

‡ *m.* But even then the presence of chlorides and of fluorides interferes very much.

The decolorization alluded to in Col. 13 is due to the formation of a compound of sulphurous acid and iodine (Iodosulphuric acid—SO_2,I) which is colourless.

§ *q.* The operator must, of course, make sure beforehand, that the substance in question contains no carbon or organic matter, for this would reduce the arsenic, disengage an aliaceous odour, and hence this mode of proving the presence of an acetate would no longer be admissible.

TABLE I.—D.

Preliminary Tests and Processes for ascertaining the probable Constituents of Compounds to be analysed.

The Substance is in the SOLID state, but is NOT A METAL NOR AN ALLOY.

Take about twenty or twenty-five grains of the Compound under examination, previously well pulverized, if necessary, by trituration in an agate mortar (Observation *a*), put this into a large test-tube, or small Florence flask, and digest it for some time therein at a boiling heat, with about half-an-ounce of pure distilled water.

DISSOLVES COMPLETELY. (Observation b.)

The solution is clear and limpid.

The compound consists of substances soluble in water, organic matter being probably absent. If an organic matter is present it will have been detected in the preliminary examination, Table I.—A., Cols. 8, 9, 10.

Examine the solution as directed in Tab. III., Col. 5 to 8, and thence go to the systematic Tables further on, according as the operator has reason to think that it is a simple or a complex compound. That is to say, Table IV. and following, or Table XIV. and following, or Table XXIII. and especially examine the compound according to Table I.—C.

(See Observ. *e* of the present Table.)

The solution is of a dark colour, and is more or less viscid.

In this case the preliminary examination, according to Table I—A., Cols. 8, 9, 10, will probably have shown the presence of an organic matter, to which the viscidity, or colour, of the solution is due, proceed, therefore, as follows:—

To a portion of the aqueous solution add a certain quantity of HCl and of KO,ClO_5, proportionate to the amount of organic matter present, and boil the mixture until the colour, or the sliminess, and all odour of chlorine have disappeared. Dilute the mass with water, filter, and treat the filtrate as directed for acid solutions, Table I.—E., Cols. 10 to 18; and also Table XXIII. If this treatment leaves an insoluble residue, treatment according to Col. 4 should be resorted to.
(Observations *c*, *e*.)

Take another portion of the aqueous solution of the compound, add thereto a certain quantity of NO_5, proportionate to the quantity of organic matter present, and boil the whole, adding more NO_5 from time to time, if necessary, until all the organic matter is destroyed, and the liquor becomes clear and limpid. Evaporate to dryness in a steam-bath, re-dissolve in water, adding a little NO_5 if necessary, filter, and treat the filtrate as for acid solutions, Tab. I.—E. 10 to 18, and Table XXIII. If this process fails in destroying all the organic matter, and in producing a clear solution, or if a residue be left, treatment according to Col. 4 should be resorted to.
(Observations *c*, *e*.)

Take another portion of the solid compound, dry it, if necessary, by means of a steam-bath, triturate the dry mass with about four times its weight of KO,NO_5, and project the mixture by small portions at a time into a red hot porcelain crucible, kept at an angle of about 45°, waiting until the deflagration has subsided before throwing a fresh portion into the crucible. Empty the mass whilst in fusion upon a porcelain slab, and, when cold, boil it for some time in water, filter, and examine the filtrate as directed in Cols. 5, 6, 7, 8.

If an insoluble residue is left, it is probably Al_2O_3, which may be at once identified by moistening a portion of it with CoO, NO_5, and heating it strongly on the hook of a platinum wire. If Al_2O_3 is present, the mass after cooling will have a fine blue colour.
(Observations *c*, *e*.)

DISSOLVES ONLY PARTLY, or NOT AT ALL, even after boiling. (Observations b.)

Leave the whole at rest for some time, in order that the insoluble portion may settle well, and according as the liquor admits or not of being filtered or decanted, treat it as directed here below.

The Filtrate.

It is CLEAR and LIMPID, and probably contains NO organic matter, which, however, will, if present, have been detected in Table I.—A., Cols. 8, 9, 10.

Test the filtrate with litmus paper.

ACID or ALKALINE Reaction.

Presence of a substance soluble in water. Treat it a second, and, if need be, a third time, with boiling distilled water, until, in fact, all that is soluble in that menstruum is dissolved (whether anything is dissolved or not is known by evaporating a drop or two of the filtrate on a platinum foil, if anything is left thereon it is of course a proof that something is still dissolved) and examine the filtrate as directed in
Table IV.,
" XIV.,
" XXIII.,
as the case may be. But first examine the filtrate preliminarily according to
Table III.
more especially.
(Observation *e*.)

NEUTRAL.

Take a small portion of the filtrate and divide it into two parts.
To the First add solution of BaCl (Observation *d*).
To the Second add KO,CO_2.

O.

Possible presence of KO—NaO—NH_4O—BO_3.
Absence of all other bases.
Evaporate a few drops of the filtrate (to which no BaCl, nor KO,CO_2 has been added) to dryness upon a strip of platinum foil. (Observation *d*.)

NO RESIDUE.

The filtrate contains nothing, throw it away.

A RESIDUE.

The filtrate contains some substance, keep it for examination, as directed in
Table IV.
" XIV.
" XXIII.,
as the case may be.
But first examine it preliminarily, as directed in
Table III.
(Observation *e*.)

Precipitate or Turbidness.

Presence of a substance soluble in water. Exhaust the original compound with water, by repeatedly boiling it with a fresh quantity of distilled water, as long as it dissolves anything, and keep the filtrate for examination, as directed in
Table IV.
" XIV.
" XXIII.,
as the case may be.
But first examine it preliminarily, as directed in
Table III.
(Observations *e*.)

It is of a DARK COLOUR, or VISCID more or less.

Treat separate portions of the filtrate, or a portion of the dry compound, as directed in Cols. 2, 3, 4.

The solution which could not be filtered.

Treat separate portions of the liquor, and a portion of the dry compound, as directed in Cols. 2, 3, 4.

The insoluble portion.

Go to Table I.—E. (Observation *e*.)

1	2	3	4	5	6	7	8	9	10	11

OBSERVATIONS ON TABLE I.—D.

Group 1 *to* 4.

a. We say pulverize the compound in an agate mortar, *if necessary*, because it is clear that if the compound be one, which is not hard, and which is soluble in water, coarse pulverization in an ordinary mortar will answer the purpose, and if it be very soluble, it may be altogether unnecessary to pulverize it. (Se also Observation *a*, TABLE II.—A.)

b. When the compound is readily soluble in water, there is, of course, no difficulty as to determining hether the compound comes under that column, but when it is difficultly or only sparingly soluble, as, for example, CaO,SO_3, one part of which requires about 400 parts of water to dissolve it, the operator may feel some doubt as to whether he should, or not, consider the compound as belonging to the present class. But it is only after the compound, having been boiled for about a quarter of an hour with the quantity of water specified in the table, fails in being dissolved completely, that regard must be had to the other columns.

See the list of compounds soluble and insoluble in water. See Table of Contents.

c. The quantity of pure hydrochloric acid employed, according to Fresenius and A. Taylor, should be rather more than the weight of the dry organic matter contained in the solution under examination, or a portion of the solid compound itself may at once be put into a porcelain capsule, and drenched with rather more than its weight of pure hydrochloric acid; as much water is then to be added as may be necessary to bring the mass to the consistence of a thin pap. The capsule, and its contents, are then heated by means of a steam-bath, and about 30 grains of KO,ClO_5 are added to the mixture, at intervals of about five minutes, until it has acquired a bright yellow colour, and has become perfectly homogeneous. When this point is attained, about two drachms more (120 grains) of KO,ClO_5 are added, and the capsule is removed from the water-bath. The whole is then to be filtered, the residue on the filter is washed with hot water, until the liquid which passes through is no longer acid, and the whole filtrate is concentrated by means of a water-bath. During this part of the process, the liquor changes from bright yellow to a brownish tint, and a saturated solution of sulphurous acid is added until an odour of this acid is distinctly perceptible, after which the whole mixture is heated for about an hour until the odour of sulphurous acid has entirely vanished. (See A. Taylor on Poisons, in reference to Medical Jurisprudence, 1848, p. 138.) The liquid is then in a fit state for the systematic analysis.

Besides these methods of destroying the organic matter present in the compound, there is another, by means of concentrated sulphuric, proposed by Messrs. Flandin and Danger, and which, especially for quantitative analysis, appears preferable to the others, inasmuch as the loss by evaporation is considerably less than with either nitric acid or aqua regia, and fusion with KO, NO_5. The *modus operandi* is as follows: —If the compound under examination is in the solid state, it should be cut into pieces as small as possible, put into a porcelain dish, and drenched with about one-third of its weight of pure concentrated sulphuric acid, (SO_3 HO.) The capsule is then placed on the fire, a gentle heat only being applied at first to prevent projection, the mass turns black and becomes more or less fluid, it should be stirred all the while with a glass rod. The dish should be heated equally all over, by placing pieces of ignited charcoal on the sides, or by other means if that fuel is not used, and this is continued until the mass. having acquired a sufficient consistence, there is no longer any danger of loss by intumescence or projection. The heat is then to be increased (short of redness) equally until all the liquid has completely evaporated.

If the charcoal resulting from the operation is *dry* and *brittle*, it is a sign that the charring is as it should be, and that the quantity of SO_3 HO employed was sufficient; but if, on the contrary, the charcoal obtained is *greasy* or *cannot be easily pulverized*, the capsule should be withdrawn from the fire, *allowed to cool*, a fresh portion of SO_3 HO added, and heat again applied, until vapours are no longer disengaged.

The capsule is then withdrawn altogether from the fire, allowed to cool; the charcoal is pulverized with a glass pestle, and moistened with aqua regia, again evaporated, until the charcoal has become dry, stirring all the while. In this state it is to be treated three consecutive times by boiling water, filtered, and the filtrate, which is perfectly limpid, and sometimes colourless, being concentrated by heat, is now ready for the systematic examination.

If the substance is in the liquid state it should be evaporated to dryness, and the dry mass being treated with about one-third of its weight of concentrated and pure SO_3 HO, is proceeded with as just described.

Group 5 *to* 8.

d. (Col. 6, 7, 8.) Although chloride of barium (BaCl) may produce nothing, yet boracic acid (BO_3) might be present if the solution be too dilute, or if there be only a small quantity of BO_3, or if a somewhat large proportion of sal ammoniac be present, since BaO,BO_3 is slightly soluble in water; whilst, on the other hand, ammoniacal salts interfere with the precipitation of BaO,BO_3—hence the necessity of evaporating to dryness on platinum foil to make sure that the filtrate contains nothing.

Group 10, 11.

e. Before going to any other Table, always make it a rule to examine whether any of the other effects or reactions mentioned in the present table are produced.

TABLE I.—E.

Preliminary TESTS and PROCESSES for ascertaining the probable CONSTITUENTS of the COMPOUNDS to be analysed.

The Substance is in the SOLID state, but is NOT A METAL, NOR AN ALLOY.

Treatment of the Compound, or Part thereof, which proved Insoluble in Water, and alluded to in TABLE I.—D. Col. 11.

The Compound contains ORGANIC Matter.

If the organic substance is fatty or oily, Ether will dissolve it; if resinous, treatment with Alcohol only, or alternately with Alchol and Ether will effect the purpose. If it be of a kind other than fatty, or oily, such a *caoutchouc*, for example, highly rectified, or freshly distilled essence of turpentine, or some other essential oil will, or may accomplish the objeet (whether an organic substance is present, will have been detected in TAB. I. A. Col. 8, 9, 10). The solution of the compound having taken place, filter, and if a residue be left, treat it with water, according to the directions given in TABLE I.—D. If insoluble in that menstruum treat it with HCl, or with NO_5, or with aqua regia, according to the directions given in this Table, Col. 3 to 22.

If the organic substance is of such a nature that none of the solvents mentioned in Col. 1, will take it up, pulverize it, or cut it up into as small fragments as possible, and treat a portion of the fragments with NO_5, by small portions at a time, as directed in TABLE I.—D. Col. 3. Treat also another portion with aqua regia, as directed in this Table, Cols. 21, 22; and lastly, treat a third portion with fused KO, NO_5, as directed in TABLE I.—D. Col. 4. See Observation a.

If whilst treating by an acid, an effervescence is produced, or an odour evolved, consult Col. 3 to 8, of this Table.

See Observation c. on Col. 2 to 4, in TABLE I.—D.

The Compound does NOT contain ORGANIC Matter.

To the portion which refused to dissolve in water, add some HCl, diluted with its own bulk of water, and after digesting it for some time therein, *in the cold*, if it has not dissolved, boil the whole; if it does not dissolve then, decant the liquid portion, and replace it by concentrated HCl, and boil in a flask, held at an angle of about 45° to prevent projections.

It DISSOLVES COMPLETELY (Observation b, c), examine the solution as the filtrate, in Col. 10, 11, 12, if while dissolving, there is—

EFFERVESCENCE, with or without ODOUR. (Obser. d.)

NO Odour.	Odour of HS.	Odour of SO_2.
Presence of a Carbonate. (Observ. *e* to *j*. Keep the solution for further examination, as directed. See TABLE IX. for bases, and TABLE VII. or XI. for acids; or see the TABLES for mixed compounds. (Obser. j).	Presence of a Sulphuret. But a Carbonate may also be present, see Observations *f* to *i*. Keep the solution for further examination. TABLE IX., for bases, TABLE VII. or XI. for acids. If a Sulphuret *insoluble in water* is present, it is better to dissolve the compound in NO_5, as directed, Col. 14, 20. If the Sulphuret should prove to be one of Pb, Sn, Sb, or Hg, it is better to use aqua regia. Observation j.	Presence of a Sulphite, or Hyposulphite, or Hyposulphate. Observation h. Go to TABLE IV. or IX., for bases. Go to TABLE VII. or XI. for acids. Observation *j*. If a Hyposulphite is present the odour of sulphurous acid will be accompanied by a yellow deposit of S.

NO EFFERVESCENCE, with or without ODOUR. (Obser. d.)

Odour of Cl.	Odour of HCy.	Odour of SO_2.	NO Odour.
Presence of certain Peroxydes, such as Mn_2O_3, MnO_2. Co_2O_3, Ni_2O_3, Pb_3O_4, $(2PbO)PbO_2$. Chlorates, Chlorites, Bromates, Iodates, Seleniates, Vanadates; Cr_2O_3, and possibly Cyanides. Observation *i*. Go to TABLE VII. or XI. and supplementary Tables for acids, and to TABLE IX. for bases. Observation *j*.	Presence of Cyanides. Observation *i*.	Presence of Sulphites or Hyposulphites. Observation *h*. Go to TABLE IV. or IX. for bases; and to TABLE VII. or XI. for acids. Observation *j*. If a Hyposulphite is present the insoluble portion will consist of Sulphur, the odour of SO_2 being in that case accompanied by a yellow deposit of that substance.	Observations *f*, *h*, *i*. Go to TABLE IX., or the Tables for mixed compounds. Observation *j*.

It DOES NOT DISSOLVE COMPLETELY, even after boiling for some time. (Observation c.)

Take a fresh portion of the original substance and boil it for some time in a sufficient quantity of NO_5, of about sp. gr. 1·2 (that is strong NO_5, sp. gr. 1·4, diluted with about its own bulk of water). Boil for some time over a spirit lamp, the flask being held at an angle of about 45°, replacing the acid, which evaporates, by fresh portions, and filter. Observation *n*.

Filter the whole whilst it is hot, and treat the Filtrate and the Insoluble portion, as follows:—Observations *k*, *l*.

THE FILTRATE.

Evaporate a portion of the filtrate to a very small bulk, and pour a few drops of it into a glass cylinder full of water.

White Crystalline Ppte.	Milkiness.	O.
Presence of Pb. The ppte. is PbCl., and if a milkiness is produced, the filtrate may contain besides Sb. Bi. Sn. In that case, add HCl, until it becomes clear. But whether it was clear or not in the first instance, or becomes so after addition of HCl, keep it for further examination, as directed at TABLE IX. Or if it is a mixed compound, go to the Tables for that class. Observation *j*.	Presence of Sb. Sn. Bi. and possibly Pb. If Pb is present, a crystalline ppte. will probably be be formed. See Observations *k*, *m*. Go to TABLE IX. Or if it is a mixed compound, go, as directed, to the Tables for that class. Observation *j*.	Examine whether the filtrate contains anything, by evaporating a drop on a strip of platinum foil, and if a residue is left, it is a proof that HCl has dissolved something. Exhaust therefore, the insoluble portion by repeated washings and filtering, and keep the filtrate for further examination, as directed. TABLE IX. Or if it is a mixed compound, as directed in the Tables for that class. Observation *j*.

The INSOLUBLE PORTION.

Observation *l*, *m*.

Boil the insoluble portion again with HCl, and ascertain whether anything is further dissolved, which is done by examining the filtrate, as directed Col. 10, 11, 12.

If nothing is taken up, wash the insoluble portion thoroughly with water, and treat it as directed, in the ensuing columns, that is to say, by NO_5, or, if necessary, by aqua regia; and if insoluble in either, as directed at Col. 22.

The FILTRATE.

Dilute a portion of the filtrate with a large quantity of water.

Milkiness.
Probably Bi. Obs. *k*, *m*. Confirm by adding A, HO in excess to the filtrate. If the milkiness disappears it was due to Bi. As other salts produce milkiness when largely diluted with water, it will be necessary to test the filtrate as in TABLE IX., or as in TABLE XXIII. according as it is a simple or a mixed compound. Observation *j*.

Dilute the filtrate with water, and add HCl.

White.			O.
Pour an excess of NH_4O on this white precipitate.			Examine whether the filtrate contains anything, by evaporating a few drops on platinum foil, and if any residue be left thereon, treat the filtrate according to the directions in TABLE IX. or XXIII., according as the substance is a simple or a complex compound. Observation *j*.
Re-dissolves.	Black.	Remains White.	
Ag. Go besides to TABLE IX., or to TABLE XXIII.; according as the substance under examination is a simple or a complex compound; and treat the filtrate according to the directions there given Observation *j*.	Hg_2O. Observation *o*. Examine the filtrate according to the directions given in TABLE IX. or if it is a complex compound, according to TABLE XXIII. Separate, however, the black precipitate by filtering, and if the clear ammoniacal filtrate on being supersaturated with NO_5, reproduces a white precipitate Ag is present also. Observation *j*.	Pb. Observation *o*. Separate by filtering and supersaturate with NO_5, the clear ammoniacal filtrate. If this reproduces a white precipitate Ag is also present. Examine, besides, the original filtrate according to the directions of TABLE IX., or if it is a complex compound, as in TABLE XXIII. Observation *j*.	

The INSOLUBLE PORTION.

Wash the insoluble portion thoroughly and digest it with a saturated solution of T,2HO.

Precipitate DISSOLVES.	Precipitate DOES NOT DISSOLVE, or only partly.
Sb. Add a few drops of HCl, and pass a stream of HS through the solution. If this produces an **Orange Red Ppte.,** certain presence of Sb. See, besides, TABLE IX., or if it is a mixed compound, go to the Tables for that class. Observation *j*.	Sb. Sn. S. Obser. *p*. Filter and wash the insoluble portion thoroughly and if on passing a stream of HS through the filtrate an orange-red precipitate is produced, it is a proof of the presence of Sb, as shown in the preceding column. If, however, a *white insoluble* residue is left on the filter, mix it with equal parts of KCy and KO,CO_2, and heat it in the inner flame of the blow pipe upon a charcoal support; if a metal is obtained, it is Sn. Obser. *q*.

Take a fresh portion of the original substance, or that which could not be dissolved either by Water, HCl, or NO_5, and having well pulverized it, boil it with Aqua regia. Observation *r*.

DISSOLVES.	DOES NOT DISSOLVE.
Obser *s*. Keep the solution for further examination, as directed. TAB. IX., or if it be a mixed compnd. as directed. TAB. XXIII. But before proceeding to systematic analysis, evaporate a portion of the solution to dryness, to see whether any silica is present, if so, the whole solution should be evaporated to perfect dryness, in order to separate the silica. Obser. *t*.	Obser. *u*. Examine the substance according to the directions given in TABLE XIII. and XXVIII. It may consist of Hg_2Cl, AgCl, PbO,SO_3, CaO,SO_3, StO,SO_3, BaO,SO_3, SiO_3, HgS, CaFl, &c. and also the following substance after having been strongly ignited, SnO_2, Fe_2O_3, Cr_2O_3 Arseniates. Phosphates.

OBSERVATIONS ON TABLE I.—E.

Group 1, 2.

a. Besides the methods of destroying the organic matters contained in the compound under examination, concentrated sulphuric acid may be employed as described in the observations *c.* on cols. 2 to 4, Table I.—D. It would appear from the careful experiments of Messrs. Flandin and Danger, that carbonization by concentrated sulphuric acid is generally to be preferred, the loss by evaporation being less by that method than by any other.

b. If the compound dissolves entirely in HCl it is clear that neither *silver* nor a *subsalt of mercury* can be present; neither can *tantalic*, *tungstic*, nor *titanic acid* be present, since these substances are quite insoluble in HCl. *Lead*, however, may be contained in the compound, since this metal is dissolved in pretty large quantity in *hot* HCl, from which, however, a large portion separates on cooling. *Silica* may also be taken up, but on evaporating the solution to *perfect dryness*, and treating with water, a gritty powder will be left in an insoluble state.

Group 3 *to* 9.

c. Before concluding to the insolubility of the compound in HCl, take care to dilute the liquor with a sufficient amount of water, and to shake the whole well, for some substances which are only sparingly soluble, or not soluble at all in an acid solution, dissolve immediately upon an addition of water.*

d. Besides odours, coloured fumes may be evolved, the appearance of which should be carefully noted, as from them a clue to the probable nature of the constituents under examination may be obtained. For example, if *reddish fumes* appear, they may be due to the presence of a bromate, in which case they consist of gaseous bromine, possibly mixed with O; or they may be due to the presence of a nitrite, in which case they consist of nitrous acid, &c.

e. A carbonate may often be present, and yet, when decomposed by an acid, effervescence either may not take place, or may escape notice. This happens, for example, when the quantity of the carbonate being small, or the solution too dilute, the carbonic acid disengaged is immediately dissolved by the water of the solution, or unites with a portion of the undecomposed carbonate, and converts it into a *bi-carbonate;* the operator must, therefore, add an excess of HCl, when an effervescence will immediately be produced if a carbonate is present.

f. Sulphuretted hydrogen may be present in such small quantity as to escape detection by the smell; and on the other hand a large quantity of CO_2 may be evolved along with the HS, and thus altogether escape notice; wherefore it is advisable, whilst the effervescence is taking place, to suspend over the liquor a strip of filtering paper moistened with basic acetate of lead (see Test Papers). If any HS is escaping the strip of paper will turn *brown*.

g To ascertain whether any CO_2 is escaping, the test tube should be closed with a cork provided with a bent tube plunging into a small beaker containing lime water, and covered with a pretty thick stratum of oil, in order to shelter it from the contact of the air, as represented in the fig. If a white precipitate (CaO,CO_2) is then obtained, which, on being treated by a little HCl, produces an effervescence, then a *carbonate* is present in the compound under examination. It is often necessary to shelter the lime-water from the air by means of oil as just said, since the carbonic acid, always present in the atmosphere, would produce a precipitate, or turbidness of CaO,CO_2 which might lead to error.

h. Sulphuretted hydrogen and *sulphurous acid* decomposing each other, so that sulphur is deposited and water formed, cannot, therefore, be evolved together except one of them be in excess, in which case its characteristic odour will be noticed.

i. In the same manner the evolution of *chlorine* may decompose a cyanide which may be present, and mask or destroy the odour of cyanogen. And on the other hand, if the compound under examination contains an abundant quantity of a cyanide, the odour of cyanogen (bitter almonds) evolved, may completely overcome that of chlorine, although a peroxyde capable of evolving chlorine when so treated, (such as MnO_2) may be present at the same time. Beware, therefore, of hastily concluding to the absence of these substances from an inability to detect their characteristic odour, and depend more upon positive than upon negative proofs, or in other words the evolution of an odour, when strongly marked, is characteristic, its absence is not so,

j. Before going to any other tables, however, examine whether any of the other effects mentioned in the present table are produced.

k. If the compound is, or contains sulphate of lead, the boiling HCl employed will convert a portion of it into chloride of lead, which will precipitate in beautiful brilliant crystals as the liquor cools.

Group 10 *to* 13.

l. After treating the substance with HCl, the residue left may be nothing but *sulphur* resulting from the decomposition of the substance by the acid. The operator should, therefore, try whether it is so by heating a portion of the precipitate on a strip of platinum, when, if sulphur be present, the characteristic blue flame, and odour of burning sulphur will be perceived.

m. The neutral and basic salts of Bi and of Sb only, are insoluble in water, but the acid salts of these metals are readily soluble therein. Wherefore, shortly after, if the solution in HCl be allowed to continue to fall in the water of the tube or glass cylinder, the milkiness at first produced gradually disappears, because the excess of HCl employed re-dissolves the basic salt or oxychloride ($2Bi_2O_3$) Bi_2Cl_3 at first produced, and which caused the milkiness or turbidnes. This milkiness, however, may be re-produced by diluting with more water.

Group 14 *to* 22.

n. If the compound under examination is a *sulphuret* insoluble in water, treatment with NO_5 is preferable to that with HCl, *in that case abundant suffocating vapours of nitrous acid of a brownish-red colour are evolved, especially when heat is applied*, and the liquid generally becomes milky, owing to a deposit of sulphur, which, by continued boiling, eventually agglomerates into yellow lumps, which are quite characteristic. A portion of the sulphur of the sulphuret, however, is converted into *sulphuric acid*, so that if the solution be now treated with BaO,NO_5, a white precipitate of sulphate of baryta will of course be produced.

If the preliminary examination has shown the presence of SbS, SnS, PbS, HgS, treatment with *aqua regia* is preferable to NO_5.

Group 14 *to* 18.

o. The *black* precipitate of *mercury*, or the *white* precipitate of *lead* may be at once identified as mercury or as lead by treatment before the blow-pipe, as directed in the Dictionary of Tests, for identifying substances.

Group 19, 20.

p. If the insolubie portion is in *yellow lumps*, or in *yellow* or *greenish-yellow* masses, which further boiling with NO_5, or concentrating, is capable of agglomerating into *yellow lumps*, it is *sulphur* which may be easily identified as such by inflaming it upon a strip of platinum foil. If sulphur is present, the filtrate will be precipitated white by an addition of BaO,NO_5 thereto as we have had already occasion to remark at Observation *n*.

q. The best way to obtain the proof of the presence of the metal is to remove the portion of charcoal on which the assay has been made, to pulverize it by strong trituration in an agate mortar, and to wash the charcoal away by elutriation, the metal is then left in spangles behind.

Group 21, 22.

r. Whether the compound is soluble or not in HCl, if it is a *sulphuret* it is better to dissolve it in NO_5, and if it be a *sulphuret of mercury*, *of tin*, *of antimony*, or *of lead*, aqua regia is preferable, for reasons which have been given in the Observation *n*. If the substance is a mixed compound of antimony containing much lead, the solution, on cooling will deposit chloride of lead in spangles, or in grains.

s. During the boiling of the substance with *aqua regia*, an insoluble precipitate may also be produced, owing to the reaction of the nitric acid or of the *aqua regia* upon one of the constituents of the substance under examination.—If, for example, the compound contains a sulphuret of lead, or a sulphuret and a lead compound, the oxydisation of the sulphur by the nitric acid or *aqua regia* employed, will produce sulphuric acid, and consequently an insoluble precipitate of sulphate of lead, accompanied or not by a separation of pure sulphur.

t. The *perfectly dry* mass should be drenched with concentrated HCl and left for about a quarter of an hour at rest; distilled water is then added, the whole is boiled and filtered; the insoluble gritty white powder is *silica;* the filtrate, if it contain anything, is, of course, kept for further examination.

u. Remember, that the portion of the compound which refused to dissolve in *aqua regia*, may be nothing else than sulphur, as already alluded to in observations *n*, *p*.

The substances in col. 22, insoluble in water and in acids, *even in aqua regia*, must be preliminarily examined before being submitted to systematical analysis. Their colour is already a clue to the detection of their nature; thus, for example:—

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* *c.* If while boiling the substance with HCl it turns *grey*, it is probably due to a reduction of metallic mercury. *See* the action of HCl upon subsalts of mercury in the Dictionary.

Sulphuret of mercury (HgS)	Obtained by precipitation	Black.
	Ditto by sublimation	Red.
Peroxyde of iron (Fe_2O_3)	In masses	Black.
	In powder	Brick Red.
		Drab.
Peroxyde of tin (SnO_2) after strong ignition		Yellowish.
Subchloride of mercury, calomel, (Hg_2Cl)	In the ordinary state	White.
	When pulverized	Yellow.
	By exposure to solar light	Black.
Oxyde of chromium (Cr_2O_3), after strong ignition		Grass Green.
Chloride of silver (AgCl)	Recently precipitated and sheltered from solar light	White.
	By exposure to solar light	Black.
	By exposure to diffused light	Brownish.
		Purplish.
	When melted	Yellow.
Sulphate of lead (PbO,SO_3)		White.
Sulphate of lime (CaO,SO_3)		White.
Sulphate of strontia (StO,SO_3)		White.
Sulphate of baryta (BaO,SO_3)		White.
Silica (SiO_3)		White.
Acid arseniates		
Acid phosphates		

TABLE II.—A.

Preliminary TESTS and PROCESSES for ascertaining the probable CONSTITUENTS of substances to be analyzed.

The substance is in the SOLID state, and is a METAL or an ALLOY, or HAS A METALLIC appearance.

The substances which are neither Metals nor Alloys, but which have a Metallic appearance, are most of the *natural* SULPHURETS, ARSENIURETS, ARSENIOSULPHURETS, SELENIURETS, TELLURETS; a few natural Metallic Oxydes, such as Oxyde of Tin, Oxyde of Iron, Oxyde of Manganese, and Oxyde of Titanium.

Take a small portion of the substance, previously well pulverized, and heat it on a charcoal support, in the reducing or deoxydising, or inner flame of the blow-pipe. (Observation a.)

No Change.	Fuses without Incrustation and without Odour.				Fuses *with incrustation*, but NO Odour.	Odour of decayed Raddish.	Odour of burning Sulphur.	Odour of Garlic.	Mix a portion of the substance with NaO,CO_2, moisten with saliva to make a cohesive mass, and heat it upon charcoal in the inner or deoxydizing flame of the blow-pipe.	
Possible presence of Pt—Fe—Mn—Ni—Co—Cr. These substances have already been mentioned. TABLE I.—B. Col. 18 to 24.	The Metallic Bead produced is				Presence of Sb. Zn. Bi. Pb. Cd. or a Telluret. The re-actions which characterise these substances have been alluded to in TABLE I.—B. Col. 13 to 17. (If no odour has been produced, examine besides, as at Col. 10, 11, 12). If the incrustation produced is *white*, and *very volatile*, and imparts to the flame of the blow-pipe a	Presence of a Seleniuret. See TABLE I.—A. Col. 20—23.	Presence of a SULPHURET. (Observation b.) Sb_2S_3 fuses under the first impression of the heat, and spreads on the charcoal; a white volatile incrustation takes place; thick white fumes are evolved. Confirm, as to the substance being a sulphuret, as described, Col. 12. Look for the base of the sulphuret in the preceding tables, if it have not already been detected.	Presence of an ARSENIURET. Go to Col. 10, 11.	Odour of Garlic. Presence of an ARSENIURET, or of an ARSENIO-SULPHURET. Remove the scories from the charcoal, and put them upon a clean piece of silver, moisten the mass with a small drop of HCl; if this produces on the piece of silver	O. Remove the scories from the charcoal, transfer them to a clean piece of silver, and moisten the mass thereon, with a drop of HCl; if this produces on the piece of silver a
	Gold Yellow.	**White.**		**Copper Red.**						
	Very malleable. Cannot be oxydized in the outer flame. Au. Confirm by dissolving the metallic bead in aqua regia, and examine the solution with the proper tests for Au. See Dictionary.	Hard. Very malleable. Cannot be oxydized by the outer flame. Ag. Confirm, by dissolving the metallic bead in NO_5, and if the addition of HCl to the solution produces a white curdy precipitate, immediately soluble in NH_3, and re-precipitated by NO_5, the presence of Ag is certain.	Hard. Malleable. Immediately oxydizes by the outer flame, and becomes covered with a white crust, which is not volatile. Sn. Confirm by dissolving the bead in HCl, and apply the proper tests. See Dictionary.	Very often no metallic bead is obtained, the metal being reduced into very fine spangles, which sink in the charcoal; in such a case, the charcoal should be pulverized and washed away; the spangles of copper will then be left behind, which may be recognized as such, by their characteristic colour. Cu. Confirm by dissolving the spangles in NO_5, dilute with water, and test with NH_3. This will produce a *blue colour*; supersaturate the NH_3 with excess of A,HO, and add solution of K_2Cfy—Crimson precipitate.	**Fine Deep Green Colour.** Presence of Telluret. N. B.—Antimony, under the same treatment, imparts only a very pale green colour to the flame of the blow-pipe. See besides, TABLE I.—B. Col. 1, 2.				**A Brown Stain.** Presence of an ARSENIO-SULPHURET. An odour of HS is often evolved at at the same time. Confirm by fusion, with $NaO, CO_2 + KCy$, as described, TABLE I—A. Col. 12.	**O.** Presence of an ARSENIURET. Confirm by fusing with $NaO, CO_2 + KCy$, as described, TABLE I.—A. Col. 12.	**Brown or Black Stain.** Presence of a SULPHURET. This treatment with a drop of HCl. generally evolves, at the same time, an odour of HS.
Pt—Fe—Mn—Ni—Co—Cr.	Au.	Ag	Sn.	Cu.	Sb—Zn—Bi—Pb—Cd.	Seleniuret.	Sulphuret.	Arseniuret.	Arseniosulphuret.	Arseniuret.	Sulphuret.
1	2	3	4	5	6	7	8	9	10	11	12

OBSERVATIONS ON TABLE II.—A.

a. It is always advisable, when that is possible, to pulverize the compound thoroughly before submitting it to treatment before the blow-pipe, in order, amongst other reasons, to prevent decrepitation, which, without this precaution, almost invariably takes place. If the substance be in lumps and very hard, wrap it up in a stout piece of brown paper, and crush it by means of a blow with a heavy hammer, or by squeezing it in a strong vice. The crushed pieces may then be more or less easily pulverized by trituration, *in small portions* at a time, in an agate mortar.

b. Most metallic sulphurets fuse when heated upon charcoal before the blow-pipe, but the odour of sulphurous acid cannot always be thus detected. The best test is that described in Col. 12, namely, fusion with carbonate of soda (NaO,CO_2) before the blowpipe, and the black stain which is produced by putting the fused mass upon a piece of clean silver, and moistening it thereon with dilute HCl.

TABLE II.—B.

Preliminary TESTS and PROCESSES for ascertaining the probable CONSTITUENTS of Compounds to be analyzed.

The Substance under examination is in the SOLID State, and is a METAL, or an ALLOY, or it has a METALLIC appearance (the latter substances have been enumerated, TABLE II.—A.).

Put a portion of the Metal, or of the Alloy, into a Florence flask, held over a spirit-lamp, at an angle of about 45°, pour upon it a sufficient quantity of NO_5, of about specific gravity 1·2 (such an acid is obtained by adding to strong NO_5, of specific gravity 1·4, rather more than half its bulk of water), boil for some time, or as long as any action is observed, adding more acid now and then, *by small portions at a time*, and, if necessary, dilute the liquor with water, (this addition of water is sometimes necessary to complete the solution, that is, to keep in solution the salt resulting from the action of the acid), if this addition of water produces a milkiness, pay particular attention to Col. 4.

It DISSOLVES COMPLETELY, either at once or after the addition of a little water. (See Observation *m* in TABLE I.—E.)

Pour a small portion of the solution into a long glass test-tube full of water.

No MILKINESS is produced.

To another small portion of the solution, add HCl, and *boil*.

White.

Presence of Ag Hg_2O—Pb.

Treat the rest of the solution, if it contains anything, as described in TABLE IX., &c., or, TABLE XXIII., Observation *a*.

If Pb or Hg_2O are present, the addition of HCl to the nitric acid solution may also produce a white precipitate, but these precipitates are re-dissolved by boiling, and by dilution with water. Moreover, the precipitate produced by HCl in solutions can be identified as AgCl — Hg_2Cl, or PbCl, because AgCl is immediately dissolved by NH_3, Hg_2Cl is turned black by it, and PbCl is left unaltered. (Observat. *b*.)

Ag—Pb—Hg.

O.

Examine whether the rest of the solution contains anything, by evaporating a few drops on platinum foil; if a residue be left, treat the rest of the solution as at TABLE IX., or, if it be a complex compound, as described in TABLE XXIII., &c. (Observat. *a*.)

MILKINESS is produced.

Presence of Bi (and perhaps of Hg_2O). *Apply heat*, filter, and to the filtrate add HCl.

White. Immediately soluble in NH_3.

Presence of Ag.

Treat the rest of the solution as described at TABLE IX., or if it be a complex compound, as described TABLE XXIII., &c. See Col. 1. (Observat. *a*.)

Ag.

O.

Probable presence of Bi.

Treat the rest of the solution, if it contains anything, as described at TABLE IX., &c., or, if it be a complex compound, as described TABLE XXIII., &c.

Bi.

It dissolves only PARTLY, or NOT AT ALL. (Filter, or carefully decant, the liquor.)

The Filtrate.

Examine whether the filtrate contains anything. This is done by evaporating a drop of it upon a *clean* piece of platinum foil; if any residue is left thereon, test the filtrate as directed in Cols. 1 to 4, and then as at TABLE IX., or, if it be a complex compound, as at TABLE XXIII. If no residue is left, throw the liquor away.

The insoluble portion is

A Metallic powder, or, consists of Metallic spangles.

Presence of Au—Pt. Possibly, also, Cr—W—Ta—Ti—Ce—Os—Rh—Ir., for which, see supplementary TABLES.

Wash the precipitate well, and treat it by Aqua Regia; when dissolved, divide the solution into two portions.

First Portion.	Second Portion.
Test with KCl.	Test with FeO,SO_3.
Yellow.	**Black or Brown.**
Pt.	Au.
Before treating with KCl, the solution should be concentrated.	The supernatant liquor has a bluish colour. If only a trace of Au is present, or if the solution be too dilute, a blue colour only will appear, but by standing, a brown precipitate of metallic Au takes place.
Pt.	Au.

A White or Yellowish Powder.

Probable presence of Sn—Sb. (Observations *c*, *d*, *e*.)
Wash the precipitate well, and boil it with a saturated solution of $\overline{T}$,2HO.

DISSOLVES completely.

Sb.

Add a few drops of HCl to the solution, and pass a stream of HS through it. If it produces an

Orange Red Precipitate.

Sb.

Dissolves only PARTLY, or NOT AT ALL.

Presence of Sn alone, or mixed with Sb. Filter, and treat the filtrate as if the precipitate had completely dissolved, and, therefore, as in Col. 8. Mix the white insoluble residue with equal parts of NaO,CO_2 and KCy, and heat the mixture in the inner flame of the blow-pipe, on a charcoal support.

Metallic Bead, or Spangles.

If the metallic bead is quite soft, and not very brilliant, Pb alone, or Pb and Sn. If more or less brittle, Sb, with either Pb or Sn, or both. If very brittle, Sb alone. (Observation *f*.)

Separate the metallic bead or particles from the charcoal by trituration of the part of the charcoal on which the fusion took place, transfer it to a glass test-tube, and boil it therein with pretty strong HCl. If the metallic particles are quite insoluble, or nearly so, in the HCl, Sb alone is present.

Before the whole of what may be soluble in HCl has been taken up, test a portion of the solution with $AuCl_3$. (Observation *g*.)

Purple.

Sn.

Sn.

Dilute the solution with water, and boil, test a portion of the liquor with NH_4S.

Black.

Insoluble in excess of NH_4S. Test another portion with KI.

Yellow.

Pb. (Observat. *h*.)

Add aqua regia and boil until a considerable portion of the liquor has evaporated, that is, until it is of a syrupy consistence, then pour a drop of the liquor into a tall cylinder full of water.

Milkiness, or White ppte.

Sb.

Confirm by HS, as in Col. 8.

Yellow Lumps.

S.

The compound, therefore, was a sulphuret. Filter,

Examine whether the filtrate contains anything, by evaporating a drop of it on a platinum foil, and exposing it to a red heat thereon. If any residue is left, treat the filtrate as directed, TABLE IX., or if it is a complex compound, as in TABLE XXIII.

Inflame the insoluble portion.

Blue flame,

and odour of SO_2.

S.

(Observat. *i*.)

Any other Colour.

(Observation *d*.)

Boil the insoluble residue in aqua regia.

Dissolves.

Keep the solution for examination, if it contains anything, as described, TABLE IX. or, if it is a mixed compound, as in TABLE XXIII.

Does NOT dissolve, at least, completely.

Filter, and examine whether the filtrate contains anything, if it does, treat it as if the insoluble portion had completely dissolved. See Col. 14.

Treat the insoluble portion as in TABLE XIII., or XXVIII., as the case may be.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

OBSERVATIONS ON TABLE II.—B.

Group 1, 2.

a. Before going to another Table always examine whether any of the other effects mentioned in the present one are produced.

b. If, however, the solution contains these three metals, namely, Ag, Hg, and Pb, they may be at once identified by treating the precipitate produced by HCl with NH_4O, which will dissolve the Ag, so that on filtering and supersaturating the filtrate with NO_5, the precipitate of AgCl will be re-produced. The precipitate on the filter may then be tested for Hg and for Pb, as described, Table I.—A. Col. 16, 17; and Table I.—B. Col. 15.

Group 8 *to* 10.

c. Bear in mind that an insoluble precipitate may also be produced by the action of nitric acid upon one of the constituents of the substance under examination; if for example the substance contains, or is a sulphuret of lead (PbS), the NO_5 employed will oxydize the sulphur, and sulphuric acid being thus produced, sulphate of lead (PbO, SO_3) will be left as an insoluble white residue. In all cases, therefore, when an insoluble white residue is left after treatment with NO_5, the operator will do well to reduce it by treatment with NaO, CO_2, upon a charcoal support, before the blow-pipe, and after having dissolved the metallic bead obtained in NO_5, to treat the solution for lead with HS, or with KI, or with $KO, 2CrO_3$. See the tests for lead. The white insoluble powder (especially in ores which have a metallic appearance) may also be silica, or alumina, or tin.

d. The residue may also have a yellowish or a red colour, which may be due to the presence of peroxyde of iron, &c.; wherefore, the insoluble residue, whatever may be its colour, should be tested for Sn and Sb, as said in the Table, but should certainly be treated as described in Col. 13, 14, 15.

e. Nitric acid has an exceedingly powerful action on metals, except the following:—

Cerium,	Platinum,
Chromium,	Rhodium,
Gold,	Tantalum,
Iridium,	Titanium,
Osmium,	Tungsten.

At the ordinary temperature nitric acid attacks almost all the metals, they abstract oxygen from it, and, accordingly, decompose it.

Poured upon lead, bismuth, manganese, copper, mercury, silver, palladium, *nitric oxyde* is evolved, which, as it comes in contact with the air, produces ruddy fumes, and a metallic nitrate remains in solution, thus:—

$$3Pb + 4\ NO_5HO =$$
$$3PbO,NO_5 + NO_2 + 4HO.$$

Poured upon arsenic, molybdenum, vanadium, antimony, *nitric oxyde* is also evolved, but the metal is transformed into a metallic acid.

Poured upon tin, the metal is easily oxydized, *nitrogen*, *nitrous* and *nitric oxyde gas* being disengaged; *nitrate of ammonia* is formed, and insoluble *peroxyde of tin* (metastannic acid) remains.

Poured upon potassium, and the metals of the first and second section, upon zinc, cadmium, iron of the third section, nitrogen, or nitrous or nitric oxyde gas is disengaged, nitrate of ammonia and a metallic nitrate are formed. Nitrate of ammonia is produced only when a certain quantity of water has been decomposed.

Group 9 *to* 11.

f. The white precipitate which refused to dissolve in the hot saturated solution of $\overline{T}, 2HO$, may consist of Sb alone, because in this form, Sb_2O_3 is not very soluble in $\overline{T}, 2HO$.

g. It is necessary to test the solution of the bead in HCl before all of that which can be dissolved by that acid has been taken up, for, otherwise the Sn Cl would become converted into $SnCl_2$, which gives no re-action with $AuCl_3$.

h. The addition of KI to the original acid solution will produce a yellow colour, which a beginner sometimes attributes to the presence of a trace of Pb, but which is due to a separation of iodine from the decomposition of KI by the acid of the solution. This yellow colour is not altered by NH_4S, whilst this re-agent immediately renders it black when lead is present.

i. The yellow lumps of sulphur have often a speckly appearance from intermixture with portions of the undecomposed compound, which are sheltered by the sulphur from the action of the acid. The sulphur might be entirely converted into sulphuric acid by fresh additions of NO_5, which would, at the same time, of course, dissolve these small specks of undecomposed substance; but this very often requires a considerable time; it is, therefore, much more expeditious to transfer the lumps to a small porcelain crucible, and to burn the sulphur away. The residue, which consists of the undecomposed substance, may then be at once dissolved in nitric acid or aqua regia, as the case may be.

TABLE III.

Preliminary TESTS and PROCESSES for detecting the probable CONSTITUENTS of COMPOUNDS to be analysed.

The substance is in the LIQUID state.

Evaporate a few drops of the liquid under examination on a strip of Platinum Foil, to ascertain whether it contains anything in solution. If a residue is left, it proves, of course, that it does contain some soluble matter. If so, evaporate a certain quantity of it to dryness in a capsule at a moderate heat, and then submit the dry residue that will be thus obtained to preliminary examination, as described, TABLE I.—A., B., C., D., E. If in doing so the residue turns BLACK from charring, and if the charred mass, or portions thereof, on being projected into fused KO, NO_5, deflagrates, as described in TABLE I.—A., Col. 8, 9, 10, an ORGANIC MATTER is present, and the compound or liquid should be examined according to TABLE I.—D., Col. 1 to 9, and TABLE I.—E., Col. 1, 2.

But whether the liquid leaves a residue or not, by evaporation, test it with blue and with reddened litmus paper, in order to ascertain whether it has *an acid*, or an *alkaline re-action*, or whether it is *neutral*.

NO RESIDUE by evaporation, and NO CHANGE by TEST PAPERS.	A RESIDUE left by evaporation, but NO CHANGE by TEST PAPERS.	Whether a residue is left or not. If the liquid has an ACID RE-ACTION, turning BLUE LITMUS PAPER RED, it is a proof of the presence of a FREE ACID, or of an ACID SALT, or of a SALT of the HEAVY METALLIC OXYDES. Pour about a thimbleful of the liquid under examination (or less, if that quantity cannot be spared), into a test-glass tube, and stir it with a glass-rod, the extremity of which has been previously dipped in a dilute solution of KO, CO_2. (Observation *a*.)				The liquid is ALKALINE, or has an ALKALINE RE ACTION turning Red Litmus Paper Blue.
Distil a portion of the liquid; the distillate, perhaps, may now be identified (if it has not been recognised before already) as being, or containing Water, Alcohol, Ether, Naptha, &c., by the taste, smell, and other means, physical or chemical.	The residue left may be examined according to the directions in TABLE I.—A., B., C. The substances in solution are probably— Alkaline Salts, Alkaline Earths, Neutral Salts. (It may have a dark colour, or a viscid consistence from the presence of organic matters in solution. Go to TABLE I.—D., and treat it as directed in Col. 1 to 4). If it is neither viscid nor dark-coloured, go to TABLE IV., and following; or if it is a mixed compound, according to Table XIV., and following.	The liquid remains clear, or the precipitate or turbidness at first formed is RE-DISSOLVED by stirring. Probable presence of a FREE ACID; or of an ACID SALT. The preliminary examination will probably give a clue to the nature of the substance, which, besides, should be looked for in the SYSTEMATIC ANALYSIS of the compound, as described in the subsequent TABLES IX. and following. (Observation b.) Or, if it is a mixed compound, go to TABLES XXIII., and following.	The TURBIDNESS or the PRECIPITATE produced is NOT RE-DISSOLVED by stirring. Probable presence of a METALLIC OXYDE. All metallic oxydes are precipitated by KO, CO_2, except those of potash, soda, and ammonia. If, therefore, a residue is left by evaporation, and a permanent precipitate is produced by KO, CO_2, all the bases may be present, and should be looked for in the SYSTEMATIC ANALYSIS of the compound, as described in the subsequent TABLES IV., and following. (Observations *c*.) Or, if it is a mixed compound, go to TABLES XIV., and following.	If the liquid, being *largely diluted* with WATER, becomes TURBID or MILKY (concentrate the liquid by evaporation, if necessary, and pour a few drops of it in a long test-tube full of water. If the water becomes turbid or milky),			The liquid may may contain— A Free Alkali, Carbonate / Borate } of Alkali. Tribasic Acetate of Lead, Free Alkaline Earth, Sulphuret of Alkali, Alkaline Cyanide, Earthy Cyanide, Insoluble Cyanide dissolved in an Alkaline Cyanide, Metallic Sulphuret dissolved in, or combined with, an Alkaline Sulphuret, such as— Sulphuret of Antimony, " of Arsenic, " of Gold, " of Iridium, " of Molybden, " of Platinum, " of Tellurium, " of Selenium. (See Observations *e*.) Go to TABLE IV., and following. " " XIV., and following; or the supplementary TABLES.
				Presence of Salts of Sb—Bi—Sn—or of $(3PbO)\bar{A}$—possibly also of HgO, SO_3—$Hg_2O\ NO_5$—HgO, NO_5. Add to the turbid or milky liquid a saturated solution of $\bar{T}, 2HO$, and shake vigorously.			
				The Turbidness DISAPPEARS.	The Turbidness does NOT DISAPPEAR, filter, or decant.		
				Sb. Confirm, by adding a a few drops of HCl, and passing a stream of HS to supersaturation. Orange Red. Soluble in NH_4S. Go to TABLE IV. " IX. " XIV. " XXIII. as the case may be. Sb.	The Filtrate. Examine whether it contains anything, and if so, add thereto a few drops of HCl, and pass a stream of HS to supersaturation. Orange Red. Sb. Go, besides, to TABLE IV. " IX. " XIV. " XXIII. as the case may be. Sb.	The undissolved portion. Bi—Pb—Sn—possibly also Hg. Add an excess of $\bar{A}$,HO.
						DISSOLVES completely. Bi. Pb. Go to TABLE IV. " IX. " XIV. " XXIII. as the case may be. (Observation *d*.) Bi—Pb.	Does NOT DISSOLVE completely. Filter, and examine whether the filtrate contains anything; if so, it is probably Bi or Pb, as in the preceding column. The insoluble portion may be Sn—Hg. Take a fresh portion of the original liquid and add thereto some HCl. White. Hg. But it may also be produced by Pb or Ag present in the original liquid. Examine as direct- in the TABLES mentioned in the preceding column. O. Sn. Examine with the blow-pipe, and also according to TABLE IV. " IX. " XIV. " XXIII. as the case may be.
1	2	3	4	5	6	7	8	9	10

OBSERVATIONS ON TABLE III.

Group 3 *to* 8.

a. If the operator has only a small portion of liquid, a few drops are quite sufficient for the purpose of testing with KO, CO_2, only, in that case, *the quantity of the re-agent employed should also be small in proportion*. Thus, the operator having transferred a few drops to a watch-glass, or other small glass capsule, placed upon a sheet of white paper, he may stir the drops with a slender glass rod dipped in dilute solution of KO, CO_2, when he will immediately be able to detect whether any permanent turbidness or precipitate is produced in the watch-glass, either as it stands, or by looking through it.

b. (Col. 3.) Whether the liquid contains nothing else than a *free acid* may be ascertained by testing a small portion of it with solution of caustic potash, which produces a precipitate *with all bases* except potash, soda, and ammonia. If, therefore, the residue (if one be left by evaporation) is proved to be neither of these bases, and if *solution of carbonate of potash, or of caustic potash, produces no precipitate*, it is certain that the free acid is one of a non-volatile nature; and if no residue at all is left by evaporation, and *yet the liquid has an acid re-action, and is not precipitated by a solution of caustic potash*, a free volatlie acid is present.

c. (Col. 4.) Although the operator is directed here to look for all the bases in the subsequent systematic analysis of the compound, it is manifest that, as certain substances cannot possibly exist in a state of chemical combination, or in solution with certain other substances, the detected presence of one or more of them will render it unnecessary for the operator to look for the others. For example, it is quite evident that if the substance under examination is a liquid, and has been found to contain baryta, strontia, or lead, it will be useless to look for sulphuric acid, since the sulphates of the first of these bases are quite insoluble, and that only a trace of the two others is dissolved by water. In the same way if the addition *of a large quantity of water* fails to produce a milkiness or turbidness, it will be useless to look for antimony or bismuth, tin, or mercury. Though with respect to nitrate of mercury not only is it soluble in a small quantity of water, but further, if the liquid contains a little uncombined or free acid, no decomposition, and, consequently, no milkiness or turbidness is produced. But these particular re-actions will be mentioned in their proper places.

d. (Col. 7.) A portion of the mass undissolved by $\overline{T}$, 2HO, may besides be tested before the blow-pipe as described in Table 1.—B, col. 15, 16.

Group 10.

e. Many other substances are soluble in alkaline liquids, such as, for example, alumina, lead, antimony, tin, zinc, &c., as will be mentioned in the proper place.

SYSTEMATIC ANALYSIS.

TABLE IV.

Systematic Analysis of Compounds which are SOLUBLE IN WATER, and which are supposed to consist of only ONE ACID AND ONE BASE, or ONE METAL AND ONE NON-METALLIC BODY.

Concentrate by evaporation, if necessary (Observations *a*, *b*), a portion of the solution of the substance under examination, and add thereto a little HCl, in sufficient quantity, however, to impart a strong acid re-action to the liquid; or if the substance be solid, take 50 grains of it (previously pulverized, if necessary), and dissolve them in about one fluid ounce of pure distilled water, or more, if that is not enough to dissolve the whole (Observation *c*), and to this solution add some HCl. If an effervescence or odour is perceived, make a note of it. (Observation *d*.)

A PRECIPITATE is produced.

Pass a stream of HS through the liquid which has been previously acidified with HCl, until it is supersaturated with the gas (see Observations on Col. 6, and following), and then apply a gentle heat, nearly to the boiling point of the liquor. (See Observation *k*.)

NO Change.

Go to TABLE V.

PbO—Hg_2O—AgO.
Perhaps $\overline{Bz}$,HO—BO_3—or a basic salt of antimony in tartrate of antimony (Observ. *e*). Hyposulphite or polysulphuret. (Observations *f*, *g*.)
Shake the liquid with the precipitate produced, and to the turbid mass add an excess of NH_3.

The precipitate

is	turns	remains	
re-dissolved.	**Black.**	**White**	**or Yellow.**

Green Colour.

If the liquor being yellow or orange-red is rendered by HS, of a

Greenish Colour,

or if a precipitate,

Bluish Green,

is produced, a *chromate* is probably present. (See Observation *l*.)

Confirm by treating a portion of this precipitate with microcosmic salt or borax on platinum wire.

Emerald Green.

Confirm by testing another portion of the original liquor to which no HCl has been added with PbO,NO_5,

Yellow.

Cr_2O_3.
See TABLE VII. Col. 9.
Cr_2O_3.

BLACK.

(Observation *m*, and especially Observations *n* and *t*.)
Presence of PbO.--BiO.--CuO.--AgO.--Hg_2O.--HgO.--AuO_3.--PtO_2.-- | Te.--Pd.--Rh.

Take a small portion of the original solution and add thereto dilute SO_3, or a soluble sulphate.

White,

insol. in acids PbO. (Observ. *o*.) Confirm as directed in Col. 3, with KI and with $KO,2CrO_3$, taking a fresh portion of the original liquid for each of the tests; if a precipitate,

Yellow,

is produced, presence of Pb.
By evaporating a portion of the solution to dryness, or mixing any of the above precipitates with NaO,CO_2, and heating the mixture on a charcoal support in the reducing flame of the blow-pipe, a malleable metallic bead of lead may be readily obtained. See TAB. I--B. Col. 15.
Pb.

Evaporate a small portion of the original solution acidified, with HCl, almost to syrupy consistence, and pour it into a tall cylinder full of water.

Milkiness or White precipitate

BiO. (Ob. *p*.) To the milkiness produced add $\overline{T}$,2HO.

It does NOT DISAPPEAR.

Bi.
Confirm by testing a fresh portion of the original solution with KO,CrO_3.

Yellow.

(Observ. *q*.) Bi.
By evaporating a portion of the solution to dryness, or mixing some of the above precipitate (BiO,CrO_3) with NaO,CO_2 and heating the mixture on a charcoal support in the reducing flame of the blow-pipe, a brittle metallic bead of Bi is readily obtained. See TABLE I—B. Col. 16.
Bi.

To another small portion of the original solution add an excess of aqueous NH_3.

Blue.

CuO.
Confirm by testing another portion of the original solution with K_2Cfy.

Brown precipitate,

insol. in HCl. (Observ. *r*.) A BAR OF CLEAN IRON plunged into the original solution becomes coated with metallic copper. (See Ob. *s*.) By evaporating a portion of the solution to dryness, and mixing the dry residue or the precipitate produced by K_2Cfy with NaO,CO_2 + KCy, and heating the mixture on a charcoal support in the reducing flame of the blow-pipe, metallic Cu is produced.
See TABLE II.--A., Col. 5. TAB. I.—B., Observ. *n*.
Cu.

To another small portion of the original solution add an excess of solution of KO, a precipitate

Yellow	or White

HgO. (Observ. *t*.) Confirm by testing a fresh portion of the original solution with KI.

Bright Red.

(Observ. *t*.) A bar of metallic copper being rubbed with a rag moistened with the solution receives a bright silvery coating which a red heat evaporates.
A portion of the precipitate obtained as above, mixed with NaO,CO_2, slightly moistened and introduced into a small tube, closed at one end (see Ob. *u*. on Col. 17, TAB. I.—A.) yields, when heated by the blow-pipe, a grey sublimate in which globules of mercury may be rendered visible by rubbing with a glass-rod.
HgO.

To another small portion of the original solution add a solution of FeO,SO_3

Black or Brown precipitate,

or Bluish Colour.

AuO_3. (Observ. *u*.)
Confirm by testing a fresh portion of the original solution with SnCl.

Purple.

Test another portion of the original solution with Hg_2O,NO_5.

Black.

A bar of zinc produces a voluminous brown coating which is metallic gold.

Au.

To another small portion of the original concentrated liquid add solution of $KClorNH_4Cl$

Yellow.

Crystalline precipitate.

PtO_2. (Observ. *v*.)
Confirm by testing another portion of the original solution with Hg_2O,NO_5. (Observ. *w*.)

Orange Yellow.

Test another portion of the original solution with SnCl.

Brownish Red.

(Observ. *x*.)
Pt.

Orange Red.

Sb_2O_3.
Confirm by evaporating to a small bulk; add HCl, and dilute with a large quantity of water.

Milkiness.

To the milky liquid add $\overline{T}$,2HO and stir.

Becomes clear.

Mix a portion of the orange red precipitate produced by HS with NaO,CO_2 + KCy, and heat it in the reducing flame of the blow-pipe upon a charcoal support; bright and brittle metallic globules of Sb are obtained. Dissolve these metallic globules in aqua regia; test a portion of this solution with HS.

Orange Red

soluble in NH_4S. (Observ. *y*.)
Sb.

Brown.

SnO | Te.
Confirm by testing another small portion of the original solution with $PtCl_2$.

Brownish Red.

(Observ. *z*.)
To another portion add HgCl.

White becoming Greyish.

To another portion add $AuCl_3$.

Purple.

Mix a portion of the brown precipitate produced by HS with NaO,CO_2 + KCy, and heat the mixture in the reducing flame of the blow-pipe upon a charcoal support; a bright malleable bead of metallic Sn will be obtained.

SnO.

White.

Fe_2O_3.
The precipitate consists of S. (Observ. *a'*.)
The substances which besides Fe_2O_3 produce a precipitate of sulphur when treated by HS, are Mn_2O_3, and the acids of Mn, such as Mn_2O_7 MnO_3, also S_2O_5 SO_2 ClO_5--BrO_5-- CrO_3--IO_5--
Ascertain that the precipitate is S, as described, Col. 4.
Confirm the presence of Fe_2O_3, by testing another portion of the original solution with K_2Cfy.

Blue,

insoluble in acids.
Test another portion of the original solution with K,2CyS.

Blood-Red Colour.

Test another portion also with NH_3,

Brown,

insoluble in excess. (Observ. *b'*.)
Fe.

Yellow.

SnO_2—AsO_3—AsO_5—CdO. | Se (See Observ. *c'*.)
Add NH_3 to the liquid containing the yellow precipitate produced by HS, and then add further, an excess of NH_4S. (See Observ. *d'*.)

The Precipitate DISSOLVES.		The precipitate does NOT DISSOLVE.
Presence of SnO_2—AsO_3—AsO_5. To a portion of the original solution add NH_3.		
White ppte.	**C.**	
SnO_2—Se. Confirm by mixing a portion of the precipitate obtained by HS, or by NH_3 with NaO,CO_2 + KCy, and heat it before the reducing flame of the blow-pipe upon a charcoal support. An argentine malleable bead is obtained. Test whether it is Sn by dissolving in HCl, and then test the solution of the metallic bead in HCl by $AuCl_3$.	AsO_3—AsO_5. Confirm the presence of As by mixing a portion of the yellow precipitate, previously dried, with NaO,CO_2 + KCy, and introduce a small portion of the mixture in a small glass-tube, and proceed as directed in the Observation *f'*. To ascertain whether the arsenic exists in the original solution, as AsO_3, or AsO_5, take a fresh portion of the original solution, to which no HCl has been added, add a little AgO,NO_5, and a drop of very dilute, NH_3.	CdO. Confirm by mixing a portion of the yellow precipitate, previously dried, with NaO,CO_2 + KCy, and heat before the blow-pipe on a charcoal support; no metallic bead is obtained, but a brown incrustation is formed on the charcoal, and brown fumes are also evolved from the mass pending the reduction. (Observ. *h'*.)
Purple. (Observ. *e'*.) SnO_2.	**Lemon Yellow.** AsO_3. (Observ. *g'*.) AsO_3.	**Light Brown.** AsO_5. (Observ. *g'*.) AsO_5.

Black precipitate

is produced, insoluble in dilute acids and in alkali, AgO. (Observ. *h*.)
Ag.

Crimson Red Colour,

soluble in NO_5, in NH_3, and in a very large quantity of water, AgO. Test another portion of the original liquor with HS. If a

Grey Sublimate,

resolvable into metallic Hg, as described in Observation on Col. 16, 17, 18, 21, TABLE I—A.
Hg_2O.

Presence of PbO. Transfer a small portion of the precipitate to the edge of a strip of platinum foil, and try to inflame it.

Does not burn.	Burns with a blue flame, accompanied by an odour of SO_2.

Presence of PbO	Presence of S.

Boil the precipitate produced by HCl with a large quantity of water.

Dissolves.	Does not Dissolve.

Pb. (Ob. *j*.) Confirm. Test a fresh portion of the original solution with KI.

Yellow ppte.

Test another portion with $KO,2CrO_3$.

Yellow ppte.

insol. in NO_5, sol. in KO. Test another portion with dilute SO_3.

White,

insoluble in acids. Treat before the blow-pipe with NaO,CO_2.

Bead of metallic lead.
Pb.

S. Presence of a hyposulphite, or of a polysulphuret.
S.

OBSERVATIONS ON TABLE IV.

GENERAL REMARKS.

a. Before proceeding with this table, the operator should bear in mind what are the substances of which the preliminary examination will have indicated the probable presence; he should also examine the table of substances soluble in water, in order to see which of them are likely to become the subject of the research.

b. The first direction is to concentrate the liquid, *if necessary;* for it is evident that, if a large precipitate is left by the evaporation of a few drops on a platinum foil, or if a few drops of any reagent (of KO, for example) produces a large precipitate, it is useless to concentrate the liquid.

c. Instead of taking 50 grains of the solid compound, the operator may (if there be enough of the substance) dissolve at once 100 grains of the compound in about 2 ounces of water, and divide it into two portions, one of which he devotes to the examination for bases, and the second to the examination for acids.

The substances not tested for in this table will be found in the special tables.

d. If, on acidifying the aqueous solution of the compound, an effervescence *or odour* is perceived, it is important to note it down, since this may give at once a clue to the nature of the acid, or of the non-metallic body combined with the base subsequently to be confirmed in the systematic analysis, TABLE VII. and following. Thus, an effervescence indicates the presence of carbonates, or of sulphurets; an odour of sulphuretted hydrogen, that of sulphurets; an odour of cyanogen, that of cyanides; an odour of chlorine, that of one of the peroxydes, or other salts mentioned in Col. 6, Table I.—E. An odour of SO_2, especially by boiling, indicates the presence of sulphites, or hyposulphites.

Group 1 *to* 4.

e. Besides PbO,—Hg_2O,—AgO,—WO_3,—S,—a white precipitate will also be produced in concentrated solutions by HCl, if soluble benzoates, antimoniates, urates, or basic salts of antimony, of bismuth, or molybdates, and tungstates of alkalies are present. Such precipitates, however, except the two last, are distinguished from PbO,—Hg_2O, AgO, & S, because they are all soluble in an excess of HCl; it is, therefore, sufficient to add such an excess of HCl to the solution, and to wash the insoluble precipitate, which may be PbCl,—Hg_2Cl,—AgCl, or tungstic acid, or sulphur, as just said.

If silver, mercury, or lead are present, the two first only of these substances can be entirely precipitated from the solution by HCl, provided enough is employed for the purpose: lead, however, being slightly soluble, cannot be removed in this manner, and, consequently, some lead being left in solution, regard must be had to this circumstance in the subsequent steps of the analysis. In order to know whether mercury exists in the solution in the state of a sub-salt, or of a per-salt, test the original solution, as directed in Col. 2 and 10.

f. Remember that solutions of cyanide of mercury (HgCy), perchloride of mercury (HgCl), and other per-salts of mercury, are not precipitated by HCl. If HCl produces a white precipitate, it indicates, as we said, (Observ. *e*), the presence, not only of PbO—AgO—Hg_2O, &c., but likewise of S_2O_2. If the latter substance be present, the precipitate (sulphur), which is white in the first instance, becomes lemon-yellow, especially by boiling, and its formation is accompanied by an odour of SO_2. The production of this yellow precipitate of sulphur and odour of SO_2 establishes the difference between SO_2 and S_2O_2; both evolve an odour of SO_2 when treated by HCl or by SO_3HO; but hyposulphites yield besides a yellow deposit of sulphur, which sulphites do not. Polysulphurets are also precipitated, white or yellow, by HCl, the precipitate is sulphur, and it is accompanied by a powerful odour of HS.

g. The precipitate, moreover, may be due to the presence of a silicate of alkali, a tungstate of alkali, of magnesia, of vanadium, or of molybdenum, a tantalate or titanate of alkali, the acids of which are precipitated, under certain circumstances, by HCl. (See TABLE III., Col. 10, and Observations.) The precipitate produced by HCl in solution of tartrate of antimony is readily soluble in an excess of HCl.

h. (Col. 1). The solution in ammonia of the precipitate produced by HCl is reprecipitated by supersaturating the ammonia with NO_5. If AgO has been found, it will be useless to look for AsO_5—AsO_3—BO_3—CO_2—Cl or HCl—Cy or HCy—SiO_3, the combinations of silver with these substances being insoluble in water.

i. (Col. 2). If Hg_2O has been found, it will be also useless to look for AsO_5—AsO_3—BO_3—CO_2—SiO_3—SO_3, mercury salts of that kind being insoluble in water.

j. (Col. 3). If Pb has been found, it will be also useless to look for AsO_5—AsO_3—BO_3—CO_2—HCy—PhO_5—SiO_3, lead salts of that kind being insoluble in water.

Groups 5 *to* 19.

k. The liquid to be tested by HS should not contain too much HCl, in fact it should only be acidified with it, for which purpose a few drops are sufficient, for most bases are not precipitated by HS from solutions which contain a large excess of acid. The liquid is known to be fully saturated with sulphuretted hydrogen when it smells strongly of the gas, even *after stirring* or *shaking*. It is important to pay attention to this, for by merely smelling the liquid, without stirring, the gas floating over it might induce the belief that the liquor is saturated, whilst in reality it might be far from being so. The stratum of sulphuretted hydrogen may also be removed by blowing over the surface of the liquid with a glass tube; if, after having done this, and after shaking or stirring the liquid, it smells strongly of HS, it is a sign of its being fully saturated. A long time is often required for the purpose.*

The above precautions are of the utmost importance in the analysis of complex compounds, for it is *absolutely* necessary that all that which can be precipitated by HS, or, in fact, by any other reagent, should be thus completely removed from the various liquids, since, unless this is strictly attended to, the most perplexing results, and an inextricable confusion would be the consequence of the neglect or carelessness of the operator in this respect.

The operator must also bear in mind that some precipitates take a long time for their production; such is the case with liquids containing *peroxyde of tin* (SnO_2), arsenious acid (AsO_3), and particularly arsenic acid (AsO_5). The formation of these precipitates (yellow) is hastened by heat.

If the liquid has been treated with an excess of HCl, that is, until no precipitate was any longer produced by it, it is clear that the liquor now under examination cannot contain any *silver*, nor *mercury* (except it be cyanide of mercury, or a per-salt of that metal), since those two metals being completely insoluble in HCl, may be entirely removed by that acid; *lead*, however, being to a certain extent soluble in HCl and in water, cannot have been completely precipitated, and, therefore, may be found again in the liquor at this stage of the process. Before passing a stream of sulphuretted hydrogen, it is, therefore, advisable to precipitate, by HCl, everything which that acid can remove, and to test the precipitate thus produced, as directed in Cols. 1 to 4. If the solution contain the mercury in the state of a per-salt, a fresh portion of the original solution should be treated as mentioned in Col. 10.

Group 6.

l. (Col. 6). If the liquid under examination, being originally yellow, or yellowish-green, or orange-red, was rendered at first turbid by HS, thenformed a deposit of sulphur, then darkened, and, lastly, became greenish when fully saturated, a chromate is probably present, and the chromic acid (CrO_3) is converted by the HS into Cr_2O_3. As in the present case, the liquor is only acidified with HCl, and consequently, there is probably not enough free acid present to keep the oxyde of chromium in solution, a greenish, or bluish-green precipitate takes place, which is oxyde of chromium (Cr_2O_3) mixed with sulphur; on adding more HCl to that precipitate, and boiling, a green solution is obtained. In that case the sulphur precipitated is inconsiderable, but the solution contains much SO_3 into which the greatest portion of the sulphur has been converted. In confirming with PbO, NO_5 the liquor must not contain any HCl, since PbO is precipitated by that acid.

If CrO_3 is present, the operator need not look for AsO_5—AsO_3—BO_3—CO_2—Cy or HCy,—Fl or HFl—PhO_5—SiO_3.

Group 7 *to* 12.

m. When only a small quantity of the compound is present in the liquid, the precipitate produced by sulphuretted hydrogen is often brownish-black, instead of black; or even, if the quantity is very small, instead of a precipitate, the liquid assumes only a brownish colour. In such cases it is advisable, if possible, to take a large quantity of the liquid, and to concentrate it by evaporation. †

If cyanide or any other per-salt of mercury is present, the precipitate produced by sulphuretted hydrogen is at first *white*, it then turns *yellow*, *orange*, *red*, *brown*, and finally *black*.

n. If the substance under examination, soluble in water, is cyanide of mercury, HS will finally produce a black precipitate, but most of the subsequent reagents mentioned in Col. 10 will fail in yielding the characteristic reactions of mercury, because cyanide of mercury is not precipitated by KO, nor by NH_3, nor by KI; the operator would therefore be much embarrassed. The preliminary examination, however, will have certainly shown the presence of Cy, and an odour of HCy will doubtless have been observed both at that time and when testing with HS, because cyanide of mercury is readily decomposed by HS, and transposes into black sulphuret of mercury and hydro-cyanic acid (HgCy + HS = HgS + HCy), and the liquor has therefore the odour of the latter acid. The best way to identify the presence of mercury is, to submit the precipitated black sulphuret, previously mixed with NaO,CO_2 to the action of the blowpipe in a small test-tube, when metallic mercury will be obtained; the *modus operandi* has been fully described in TABLE I.—A, Cols. 17 and 21: or the black precipitate (HgS) may be dissolved in *aqua regia*, evaporated so as to get rid of the excess of acid, diluted with HO, filtered, and the filtrate, being tested as directed in this Table with KO, &c., will yield the usual reactions.

o. (Col. 7). If lead is present, HCl will have produced a white precipitate (PbCl) (provided the liquid was not too dilute), as mentioned in Col. 3. Any of the precipitates produced in this column may be treated with NaO,CO_2 on a charcoal support before the blowpipe, as described in the preliminary process, TABLE I.—B, Col. 15; a metallic bead of lead, accompanied by a characteristic incrustation, being thus produced.

p. (Col. 8). If the solution contains too much acid, a milkiness is not produced unless a large quantity of water is employed; the great excess of acid may be neutralized by NH_3.

q. Chromate of potash (KO,CrO_3), as has been seen, Col. 7, produces a yellow precipitate with lead, as well as with bismuth solutions; but the BiO,CrO_3 differs from the PbO,CrO_3 in this, that the first is *soluble* in NO_5 and *insoluble* in KO, whilst the second is *insoluble* in NO_5, and *soluble* in KO. Besides, solutions of Bi are not precipitated by HCl.

If bismuth have been found, the operator need not look for AsO_5—AsO_3—BO_3—CO_2—Cy or HCy—Fl or HFl—SiO_3—SO_3.

r. (Col 9). In concentrated solutions the precipitate produced by K_2Cfy in solutions of copper is chocolate brown; but the more the solution is dilute, the more is the precipitate or coloration of the liquid of a hue verging towards crimson. In very dilute solutions the liquor becomes pink.

* *k.* The liquid is known also to be saturated with the gas, by violently shaking it while closing the flask which contains it with the thumb. If the operator perceives that bubbles are forcing their way out on partly relaxing the pressure of his thumb, which is at the same time gently pushed up by the pressure of the gas within, it is a proof that the liquid is fully saturated. If, on the contrary, no such effect is produced, but, far from it, if he feel that his thumb is, as it were, sucked in the flask, it is a proof that the liquor is not yet saturated, and the current of gas must be continued through it.

† *m.* Hg_2O and HgO appear here among the substances which are precipitated black by HS; but in the present group, if the black precipitate produced by HS is sulphuret of mercury, the compound must have contained it, as HgO, since Hg_2O would have been precipitated by HCl at the beginning, (see col. 2), and the present TABLE does not refer to complex combinations.

The solution which is to be tested for copper by K_2Cfy should be acid, and yet, not too acid, and especially in the latter case, the operator should use only a few drops of K_2Cfy, otherwise, that reagent being decomposed, forms a bluish solution and scanty precipitate, which, mixing with the crimson brown precipitate of the copper, produces a dingy green precipitate, which may lead to the belief that no copper is present. If, therefore, too much acid exists in the liquor it should be saturated with NH_3, so as to leave the liquor with only an acid reaction; if K_2Cfy be then added, the characteristic crimson-brown precipitate will be produced if copper is present. If too much NH_3 has been added, it is best to supersaturate it with $\bar{A}HO$, for K_2Cfy being decomposed by alkalies would, of course, produce no crimson precipitate in an ammoniacal solution. *

If copper have been found, the operator need not look for AsO_5—AsO_3—BO_5—CO_2—Cy or HCy—SiO_3.

s. If the quantity of copper deposited upon the iron blade is too small to be visible, the blade should be wetted with a solution of sal-ammoniac, and then exposed to the flame of a spirit lamp, which then assumes a beautiful and characteristic green colour. This green colour of the flame is well seen only in the dark, or in a somewhat obscure place, such as, for example, by holding the spirit lamp in the shadow of a table.

t. (Col. 10). The colour of the precipitate produced by HS in solutions of per-salts of mercury depends on the quantity of the reagents employed, or if a stream of HS is used, the colour of the precipitate produced is observed to undergo a change as the liquid becomes gradually saturated with the gas; thus the first effect of HS is to produce a white precipitate, which turns yellow, then orange-red, reddish-brown, and finally black. As we have already said, this of itself is a distinctive character. Sulphuret of mercury is insoluble in NH_4S, in KO, and in boiling NO_5; it is soluble in aqua regia and in excess of KS. The colour of the precipitate produced by KO in solutions of HgO depends also on the quantity employed, for if too small a proportion of KO is used, the precipitate, instead of yellow, is *reddish-brown*, and if a salt of ammonia is present, the precipitate is *white*. On the other hand, the solution to be tested by KO should not contain too much acid, or the excess of acid should be evaporated, since, if the quantity of acid present is large and that of the mercury small, KO will produce no precipitate, or only a very small one, and this after a somewhat considerable time has elapsed. KI always produces a red precipitate in such solutions; but take care not to use an excess of the reagent, for otherwise the precipitate will be instantly redissolved; or if too much of it is at once added, no precipitate will be produced.

u. (Col. 11). If the quantity of *gold* present in the liquid is very small, FeO,SO_3 produces only a bluish, or purplish colour though after a while a small brown precipitate falls down. †

The operator need not look for AsO_5—AsO_3—BO_3—CO_2—Fl or HFl—SiO_3—SO_3, if gold is present.

v. (Col. 12). KCl or NH_4Cl do not produce the characteristic yellow precipitate except in very concentrated solutions.

w. Hg_2O,NO_5 cannot be used as a test for platinum when HCl is present in the liquor, since, as has been shown in Col. 2, solutions of sub-salts of mercury are precipitated white by HCl.

x. The reddish-brown precipitate produced by SnCl in platinum solutions, *when dilute*, resembles that produced by NH_3 in solutions of peroxyde of iron (Fe_2O_3), and the superincumbent liquor retains for some time a reddish-brown colour, after which it becomes clear. In *concentrated* solutions NO PRECIPITATE is produced, but the liquor is intensely brown, and it gradually deepens in hue until, after a day or so, it is almost black. If platinum is present, the operator need not look for AsO_5—AsO_3—BO_3—CO_2—HCy—SiO_3.

* *y.* If antimony is present, the operator need not look for AsO_3—AsO_5—BO_3—CO_2—HFl—PhO_5—SiO_3.

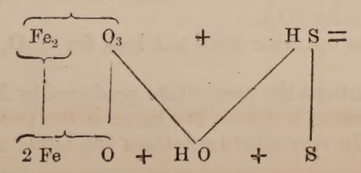
Group 14.

z. In dilute solutions of SnO, the precipitate produced by $PtCl_2$, (and which much resembles that of Fe_2O_3 produced by NH_3) leaves for some time the superincumbent liquor tinged with a brownish or yellowish red colour. In more concentrated solutions NO PRECIPITATE IS PRODUCED, the liquor has at first a blood-red colour, which gradually becomes darker and darker, until eventually it becomes nearly black. On diluting it, a precipitate resembling that produced by NH_3 in solutions of Fe_2O_3 is produced after standing for a few minutes. When the excess of HCl has been previously neutralized by ammonia, muriate of ammonia will of course exist in the liquid, and the addition of $PtCl_2$ will produce, besides the brown precipitate alluded to, a yellow one, which is due to the action of the muriate of ammonia, since $PtCl_2$ is precipitated yellow by muriate of ammonia, and by chloride of potassium.

Bear in mind, that if an excess of muriatic acid has been employed to dissolve the compound or the metallic tin reduced, a *perchloride*, instead of a *protochloride of tin*, may be formed, *especially if heat has been applied*, in which case, of course, bichloride of platinum will produce no precipitate or dark-red colour. Boiling the tin with HCl may also have produced a mixture of protochloride and of perchloride of tin, in which case the addition of $PtCl_2$ may impart only a faint amber colour to the liquor.

Group 15.

a'. The deposition of sulphur produced when HS is passed through a solution of a per-salt of iron is due to the reduction of the metal to a lower degree of oxydization thus:



and consequently the iron which existed in the original solution in the state of peroxyde of iron (Fe_2O_3), will be subsequently found in the liquor filtered from the precipitate produced by HS in the state of protoxyde of iron (FeO).

Several other substances besides Fe_2O_3 decompose sulphuretted hydrogen, and cause a deposit of sulphur; some of these, such as the highly oxydized compounds of manganese, if present, will be detected by the processes described in TABLE V., the others will be found in the analysis for the detection of the acid. The preliminary examination, TABLE I.—A., cols. 4, 5, 6, will already have shown the presence of some of them.

b'. The reaction produced by NH_3 is less delicate than either K_2Cfy or K,2CyS, but it is very characteristic.

c'. The yellow precipitate produced by HS occasionally takes a long time to appear; such is the case with solutions of *peroxyde of tin*, but more particularly with those of *arsenic acid*. The formation of the yellow precipitate is hastened by heating the liquid supersaturated with HS. If the operator have reason to believe that AsO_5 is present, or if HS has failed to produce a yellow precipitate, he will do well to add some solution of SO_2 to a portion of the original liquid, and then to pass a stream of HS through it to supersaturation. The object of this addition of SO_2 is, to convert As O_5 into As O_3, which is much more easily precipitated by HS.

The yellow precipitate of *bisulphuret of tin* ($Sn S_2$) does not immediately appear, as we just said, when the acid solution is dilute; if, however, the solution, being supersaturated with HS, is then boiled, the yellow precipitate is soon produced.

Group 16 *to* 19.

d'. It frequently happens that the addition of NH_3 to the liquid containing the yellow precipitate produced by HS is sufficient to redissolve that precipitate, owing to the formation of NH_4S by the ammonia combining with the sulphuretted hydrogen with which the liquid is supersaturated, and in which (NH_4S) bisulphuret of tin and the sulphurets of arsenic are soluble. When this takes place, it is of course useless further to add NH_4S, but if the whole of the yellow precipitate is not dissolved by the ammonia first added, then hydro-sulphuret of ammonia must be poured in the liquid, in order to see whether the yellow precipitate will then dissolve.

e'. (See TABLE II.—B; Observation *g.*) If SnO_2 is present, the operator need not look for AsO_5—AsO_3—BO_3—CO_2—Cy or HCy, since the compounds of Sn with these acids are not soluble in water.

f'. (Cols. 17—18). The positive demonstration of the presence of Asin, the yellow precipitate is somewhat troublesome; the following method is both expeditious and correct:—Dry a portion of the yellow precipitate produced by HS, and mix it with one part of carbonate of soda and two of KCy, moisten the mass *very slightly*, roll a portion of it into a little oblong ball, and introduce it into a small glass tube, closed at one end, about three-eighths of an inch bore, and about four inches long. (The tube should be one of German glass, or at any rate should contain no lead). Expose the closed end of the tube, containing the little pellet above spoken of, to the heat of an ordinary spirit lamp for a short time, in order to dry the little mass under examination, taking care to hold the tube in a quite horizontal position, for otherwise the volatilized water, by running down on the heated part of the tube, would crack it, and spoil the experiment. When the mass has turned black, urge the flame of the spirit lamp by means of a blowpipe, so as to fuse the mass in the tube. A metallic mirror is obtained at a very short distance from the heated part, and may be shifted backwards and forwards in the tube, by directing the flame of the blowpipe upon it; cut the tube with a file close to the part where the mirror has been produced, and thrust the edge containing the mirror into the flame of the spirit lamp; a characteristic odour of garlic shows that arsenic is present. Put now the part of the tube containing the mirror, and that where the mass has been fused into a small glass beaker, and pour upon it some concentrated and fuming NO_5; when the whole of the mass operated upon has dissolved, dilute the whole with water, and add an excess of AgO,NO_5; a white precipitate is produced, which is AgCy, filter; if to the filtrate as much NH_3 is now added as is necessary to render it perfectly neutral, a characteristic *light brown* precipitate of arseniate of silver will be produced. It is absolutely necessary that no more NH_3 should be added than is necessary to render the solution quite neutral, or even leave it with a very slight acid reaction, since arseniate of silver is immediately soluble in a slight excess of ammonia, or of acid. If, however, a little too much ammonia has been added, the excess may be neutralized by some dilute NO_5, and *vice versâ*.

It is, however, less troublesome to begin by adding at once the AgO, NO_5 to the nitric acid solution, and then to pour some NH_3 in such a way that it may run down the sides of the tube; a light brown precipitate, or ring of arseniate of silver (AgO, AsO_5) is produced, which immediately disappears on shaking the liquor, owing to the excess of acid; but the precipitate becomes gradually more and more permanent as more NH_3 is poured in, until enough of the latter has been added to render the liquid nearly neutral, when the light brown precipitate ceases to be redissolved.

g'. If AsO_5 or AsO_3 are found, no other base can be present than the alkalies, since all other arseniates and arsenites are insoluble in water.

h'. (Col. 19). If cadmium has been found, it is needless to look for AsO_5—AsO_3—BO_3—CO_2—Cy or HCy—Fl or HFl—SiO_3.

* *r.* Acetic acid is preferable to every other acid for the purpose of neutralizing the excess of NH_3, because the reaction produced by K_2Cfy is then much more delicate, and on that account I would recommend the operator always to add an excess of NH_3 to the liquor, then to supersaturate it with $\bar{A}$,HO, and then to test the liquor for copper by pouring into it a few drops of K_2Cfy.

† *u.* When SnCl is used as a test for AuO_3, a sufficient quantity of HCl should be added to that reagent to render it clear.

‡ *y.* The operator may also pass a stream of HS through the milky solution alluded to in the TABLE, taking care to render it clear by mixing it with a sufficient quantity of $\bar{T}$,2HO, and further adding to it a few drops of HCl.

TABLE V.

Systematic Analysis of Compounds which are SOLUBLE IN WATER, and which are supposed to consist of only ONE ACID and ONE BASE, or ONE METAL and ONE NON-METALLIC Body.

TREATMENT OF SOLUTIONS IN WATER, ACIDIFIED, AND NOT PRECIPITATED BY HS.

See TABLE IV., Observation *b*.

Take a portion of the original solution (concentrated by evaporation, *if necessary*,) and dissolve therein a certain quantity of sal ammoniac (or add a solution of sal ammoniac) (Observation *a*) and add, further, as much NH_4O as will impart an alkaline re-action to the liquor (Observations *b*, *c*), and, disregarding any precipitate which such an addition may produce, pour NH_4S into the liquid under examination.

NO CHANGE. — Go to TABLE VI.

A PRECIPITATE is produced.

Whatever the colour of the precipitate may be, especially if it is not BLACK, read the Observations *e*, and especially those on Mn, Col. 5, and Zn, Col. 12, as impurities modify the colour. If the precipitate is

Black. (Observation *g*.) — Presence of FeO—NiO– CoO, possibly also U.

Flesh Red. (Observation *f*.) — Presence of MnO).

Greenish. — Presence of Cr_2O_3.

White. (Observation *f*.) — Presence of Al_2O_3—ZnO — possibly, also Gl—Y—Th—Ce—Zr) — and, if the original solution was acid, phosphates and arseniates of earths (Observation *d*).

To another portion of the original liquid add a pretty large excess of a solution of caustic KO *in the cold*.

A PRECIPITATE is produced INSOLUBLE in any excess of KO.

A PRECIPITATE is at first produced, soluble in excess of KO.

White. Dingy Green. Brownish Red.

FeO.

Confirm by testing a fresh portion of the original solution with (3K)2Cfy.

Prussian Blue.

Insoluble in HCl, decomposed by KO, by which it is rendered

Reddish Brown.

Test another portion of the original solution, concentrated by evaporation, with moderately strong NO_5. (Observation *h*.)

Blackish Brown Colour.

Boil the liquor to which NO_5 has been added with more NO_5, and test with NH_3. (Observ. *i*.)

Reddish Brown.

Presence of Fe. (Observation *j*.)

Fe.

Apple Green.

NiO.

Confirm by testing a fresh portion of the original liquid with a very slight quantity of NH_3, possibly, a precipitate of an *apple green* colour may be produced, but, whether or not such a precipitate is produced, add an excess of NH_4O,CO_2.

Greenish Blue Colour.

To this solution of a blue colour add solution of KO.

Apple Green.

Presence of Ni. (Observations *k*, *l*.)

Ni.

Fine Light Blue.

CoO. (Observ. *m*.)

Boil the blue precipitate, it will gradually become

Pinky Reddish Brown.

It is soluble in excess of NH_4O,CO_2; the solution has a beautiful

Red Purple Colour.

Confirm by fusing a small portion of the precipitate with borax, on the hook of a platinum wire, in either flame of the blow-pipe.

Blue Bead.

(Observations *n*, *o*.) Presence of Co.

Co.

White.

By exposure to the air this white precipitate becomes

Yellowish,

Blackish Brown.

Black.

MnO. (Observ. *p*.)

The most delicate test consists in boiling the solution in which Mn is suspected with red lead, and dilute NO_5. If the liquor assumes a

Fine Purple Colour,

Presence of Mn.

Confirm, besides, by fusing a small particle of the above white precipitate with NaO,CO_2, to which a small quantity of KO,NO_5 has been added, on a strip, or hook of platinum in the oxydizing flame of the blow-pipe.

Bluish White.

Mn.

Separate the precipitate by filtering.

The Filtrate. (See Observation *q*.)

Acidify the strongly alkaline filtrate by NO_5, and very nearly neutralize the excess of acid by NH_3, add then AgO,NO_5.

Brick Red.

AsO_5.

Indicating the presence of arseniates of earths, the original liquor being acid. (Observation *d*.)

Arseniates of earths.

The Precipitate.

Put a portion of this precipitate in a capsule, pour a little SO_3HO upon it, add alcohol, and inflame.

Green Flame.

BO_3.

Indicating the presence of a borate of an alkaline earth, the original liquor being acid. (Observation *d*.)

Borates of earths.

Dissolve the precipitate in as little NO_5 as possible, and divide into two portions.

First Portion.

Add an excess of AgO,NO_5 (filter if necessary) and neutralise *very nearly* the excess of acid employed by adding NH_3.

Lemon Yellow.

PhO_5.

In the state of perphosphates of earths, the original liquor being acid. (Observation *d*.) Add an excess of Fe_2Cl_3 to the whole solution, and then an excess of $KO,\overline{A}$, boil, filter, and look in the filtrate for the earths, as in TABLE VI.

Phosphates of earths.

Second Portion.

Add $KO,\overline{A}$.

White.

$\overline{O},HO$. (Observation *r*.) In the state of oxalates of earths the original liquor being acid. (Observation *d*.) Confirm by treating with $MnO_2 + SO_3HO$, and collect the gas as described in the tests for oxalic acid. The gas burns with a

Blue Flame.

(See Dictionary.)

Oxalates of earths.

Greenish White, or, White.

(Observation *s*.) Presence of $Cr_2O_3 \cdot Al_2O_3$—ZnO, possibly, also Gl.

To a portion of the *clear*, and therefore strongly alkaline, solution of the precipitate in KO just alluded to, add HS, or NH_4S.

Greenish.

Cr_2O_3.

Confirm by adding to the above solution in excess of KO, some NH_4Cl, and boil.

Bluish Green.

Evaporate a small portion of the original liquor to dryness, and fuse a particle of the dry residue (or of any of the precipitates produced) upon the hook of a platinum wire, with microcosmic salt, or borax, in either flame of the blow-pipe.

Emerald Green.

(Observation *t*.)

Cr.

O.

Al_2O_3.

Confirm by acidifying a portion of the above solution of the precipitate in KO with HCl, add an excess of solution of NH_3, and apply heat.

White.

Confirm. Take a portion of this precipitate and heat it upon charcoal before the blow-pipe, then moisten with CoO,NO_5, and heat it again strongly before the blow-pipe.

Fine Blue.

(Observation *u*.)

Al.

White.

ZnO.

(See Observation *v*.) Confirm by drying a small portion of the precipitate (ZnS) produced by NH_4S on a strip of platinum foil, moisten it with CoO,NO_5, and heat it before the blow-pipe.

Emerald Green.

ZnO. (Observation *x*.)

Zn.

1	2	3	4	5	6	7	8	9	10	11	12

OBSERVATIONS ON TABLE V.

GENERAL REMARKS.

a. The addition of sal-ammoniac is not necessary when the liquid has been strongly acidified with HCl, since the ammonia, which the operator is directed to pour into it until an alkaline reaction is attained, will produce sal-ammoniac. The presence of the latter salt is necessary to prevent magnesia from being precipitated by the ammonia and hydro-sulphuret of ammonia employed, and must be used in rather considerable quantity if magnesia is abundant. Borates, of earths if present, might also be precipitated by ammonia if the liquor did not contain enough ammoniacal salt. (See Obs. *a*, Table XVIII.)

b. Borates of earths are insoluble, or almost so, in water; but as they are readily soluble in liquids which contain a sufficient quantity of chlorides of earths, it is clear that they may exist in the liquor under examination, if the said chlorides or ammoniacal salts are present.

c. If the compound under examination contains a base which can be precipitated by NH_3, such as, for example, Fe—Cr—Zn, &c., the addition of that reagent, with a view to give an alkaline reaction to the liquor, will, of course, produce a precipitate. But even *though no base be present*, the addition of NH_3, or of NH_4Cl, may produce a precipitate which may be due to the presence only of the reagent employed; for example, suppose the solution under examination to be simply one of oxalic acid, and sufficiently concentrated, on adding NH_3 to such a solution a precipitate of oxalate of ammonia will be formed. In the same circumstances, sal ammoniac (NH_4Cl) will also produce a white precipitate. *Such precipitates, however, take place only in concentrated solutions, and disappear on diluting the liquor with water.*

d. It should also be remarked here if that arseniates, or perphosphates, or oxalates of earths are present, the liquor, *which in such cases is always acid*, on being neutralized by NH_3, yields a precipitate. Acid liquors should always be carefully tested in reference to these compounds, which have occasionally escaped detection, even though present in large quantity, when analyzed by unpractised hands. In such cases, that is, in case of solutions having an acid reaction, these compounds should be analyzed as directed in the Systematic Analysis for Compounds Soluble in Acids.

Group 2 *to* 4.

e. The black precipitate produced by NH_4S is, of course, a sulphuret either of iron, of cobalt, or of nickel; but sulphuret of iron absorbs the oxygen of the air with rapidity, and if separated by filtering, it very speedily turns brown on the filter; this, if not a characteristic reaction, yet is one from which an *a priori* inference may be drawn of the presence of iron.

If only a trace of iron is present, no precipitate takes place, or, at any rate if one is produced, it takes a very long time to subside; the liquor has then a dingy bottle-green colour.

If the hydro-sulphuret of ammonia employed contains an excess of sulphur, or if, as will be the case here, the liquid contains free ammonia, a black precipitate will be produced in solution of nickel, but the superincumbent liquor almost invariably has a brownish-black colour, due to a portion of NiS, which remains in solution.

f. The slightest impurity affects the distinctness of the lighter coloured precipitates, such as those of *manganese*, *of zinc*, and of *alumina*. A trace of iron, for example, will impart to the precipitated sulphuret of manganese, a brownish-black tinge; to sulphuret of zinc, a grey tinge, or even will produce a completely black precipitate.

Owing to this modification in the colour of the precipitates produced by NH_4S, *manganese* has often been overlooked, wherefore it is advisable, under all circumstances, to place the presence, or the absence, of that body beyond doubt, by pouring some of the original solution in a glass test-tube, adding thereto some peroxyde of lead, PbO_2, or some red lead (PbO_2, PbO), then some dilute NO_5, and heating the whole to boiling. The liquor immediately assumes a beautiful purple colour *(provided enough peroxyde of lead has been used)*, due to the formation of permanganic acid. The purple colour is immediately decolourized by solution of SO_2. In this way the most minute traces of manganese may be unmistakeably detected.

The precipitate produced by NH_4S, may consist of other metallic oxydes, besides those mentioned in the Table, but as they are rarely met with, they will be examined in the Supplementary Tables.

g. (Col. 2.) Remember that if the Fe_2O_3 existed in the original solution, it will have caused a white deposit of S, when treated with HS, as shown in Table IV., Col. 15; but as it will have been reduced to the state of FeO, by the previous treatment with HS, it now exists in the liquor under examination in the state of FeO.

h. The liquor to be tested by nitric acid should be concentrated, and the nitric acid employed to produce this brownish-black colour should be moderately strong, and should not be put in excess, or otherwise the colour will immediately disappear, but it can at once be reproduced by adding more of the original solution. It is true that, if FeO is in large excess, the colour will likewise disappear, because it will absorb oxygen from the air, but that requires a much longer time than when nitric acid is put in excess.

i. By boiling with excess of NO_5, the FeO is, of course, converted into Fe_2O_3, and hence the reddish-brown precipitate (Fe_2O_3), produced by testing with NH_3.

j. it is needless to look for AsO_5—AsO_3—BO_3—CO_2—Cy or HCy—Fl or HFl—PhO_5—SiO_3, if Fe be found.

k. (Col. 3.) The reproduction of the precipitate, by pouring KO in the ammoniacal solution, is quite characteristic for the purpose of distinguishing nickel from cobalt, for the latter is not reprecipitated by KO from such a solution.*

l. If Ni is present it is needless to look for AsO_5—AsO_3—BO_3—CO_2—Cy or HCy—Fl or HFl—SiO_3.

m. (Col. 4.) The precipitate produced by KO becomes reddish or greenish by exposure to the air, this change is due to an absorption of oxygen. This precipitate is soluble in neutral NH_4O,CO_2, forming a liquor of a magnificent purple-red, or fine red amethyst colour, which is not reprecipitated by KO, or triflingly so, and which does not turn brown by exposure, as is the case with NH_3.

n. This production of a blue bead with borax is quite characteristic, since no other substance behaves in this manner. A bead of the same colour is also produced in the same circumstance, by fusion with microcosmic salt. If too great a quantity of the precipitate has been fused with the flux, the bead is of such a deep blue that it appears black.†

o. It is needless to look for AsO_5—AsO_3—BO_3—CO_2—SiO_2—if Co is present.

Group 5 *to* 9.

p. (Col. 5.) The changes caused by KO in MnO solutions are more particularly observable on the parts which are in contact with the air, and are more rapid if the precipitate be thrown on a filter, since the points of contact are thereby considerably increased. The black precipitate which finally is produced is a hydrate of peroxyde of manganese. *The presence of ammoniacal salts interfere with the production of this precipitate*, wherefore, a portion of the original solution to which no NH_3 has been added, is directed to be operated upon. (See Table I.—B., Col. 23, and Observation *o*, thereon.)

q. It is needless too look for AsO_5—AsO_3—BO_3—CO_2—Cy or HCy—SiO_3, &c., if manganese has been found.‡

r. (Col. 9.) This white precipitate produced in the nitric acid solution of the precipitate is due to the decomposition of the acetate of potash by the nitric acid, whereby nitrate of potash is formed, and the acetic acid is set free, in which (acetic acid) oxalates of earths, not being soluble, are of course reprecipitated.

Group 10 *to* 12.

s. (Col. 10.) The greenish precipitate produced by KO, in solutions of Cr_2O_3, is often slight, but the solution itself is greenish, and therefore, quite distinct. If the original solution is green, or if, after the addition of an excess of KO, it has become so, the presence of Cr_2O_3, at this stage of the process, may be strongly suspected, and the solution should be tested accordingly. The addition of NH_4Cl, to the boiling hot potash solution, at once produces a bluish green precipitate of Cr_2O_3,HO, because NH_3 is evolved.

t. The emerald green coloured bead produced by fusing Cr_2O_3 with microcosmic salt or borax, in both flames, distinguishes it from copper, which, in the oxydizing flame, gives also a green bead, but in the de-oxydizing flame, the bead obtained with copper is reddish-brown or brown.

It is needless to look for AsO_5—AsO_3—BO_3—CO_2—Cy or HCy—Fl or HFl, &c., if Cr is present.

u. (Col. 11.) It is needless to look for AsO_5—AsO_3—BO_3—CO_2—SiO_3, &c., if Al is present.

v. (Col. 12.) The white precipitate produced by NH_4S, in the *colourless* and *strongly* alkaline solution, cannot consist of anything else than ZnS, and, therefore, this is of itself a sufficient confirmation of the presence of Zn. If the slightest trace of iron is present, the precipitate ZnS, instead of being white, will be grey or still darker, or even black, in proportion to the quantity of iron present.

x. It is needless to look for AsO_5—AsO_3—BO_3—CO_2—Cy or HCy—Fl or HFl—SiO_3—if Zn is present.

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* *k*. The presence of cobalt is always easily recognized by the blue glass which it yields when fused with borax before the blow-pipe.

† *n*. The blue colour, however, may always be rendered evident by smashing the bead while red hot, and then looking at it whilst holding it against the light; or else the bead may be shaken off, and the portion which adheres still to the platinum wire being fused again with a fresh quantity of borax, yields a bead of a more or less intense blue colour.

‡ *q*. The operator will do well also to look for $\overline{O}$,HO in this filtrate, since the oxalates of earths are decomposed partly by the concentrated solutions of KO and of NaO, and altogether by boiling with those of the alkaline carbonates.

TABLE VI.

Systematic Analysis of Compounds which are SOLUBLE IN WATER and which are supposed to consist only of ONE ACID and ONE BASE, or ONE METAL and ONE NON-METALLIC BODY.

TREATMENT OF SOLUTIONS NOT PRECIPITATED BY HS, nor by NH_4S.

Take a portion of the original solution, and slightly supersaturate it with NH_4O (See Observation *a*); and whether or not a precipitate or turbidness is produced, add an excess of solution of NH_4O,CO_2 and boil. (Observation *b*.)

White precipitate or turbidness INSOLUBLE IN SAL AMMONIAC, and which does not disappear by continued boiling. (See Observation *b*.)

Presence of BaO—StO—CaO.

Concentrate a portion of the original solution, by evaporation, and add thereto a solution of CaO,SO_3. (See Observations *c*, *d*.)

White Precipitate, either immediately, or after some time.

Presence of BaO — StO. (Observation *d*.)

To another portion of the original solution, concentrated by evaporation, and acidified slightly with HCl, add $SiFl_2HFl$. (Obser. *e*.)

White.

Confirm by testing a portion of the original solution with $KO,2CrO_3$. (Observation *f*.)

Yellow.

BaO.

(See Observation *g*.)

Ba.

O,

O.

Evaporate another portion of the original solution almost to dryness, pour alcohol on the residue, and stirring the mass, inflame it.

Carmine Flame.

StO.

(See Observation *h*.)

St.

O.

Presence of CaO.

Confirm by adding to another portion of the original solution neutralized by NH_4O, (Observations *a*, *i*) some solution of $NH_4O,\overline{O}$. (Observations *j*, *k*.)

White.

CaO.

(See Observation *l*.)

Ca.

White precipitate or turbidness SOLUBLE IN SAL AMMONIAC, or which disappears by continued boiling.

Presence of MgO.

White precipitate.

Presence of MgO, possibly LiO. (Observation *q*.)

Confirm by adding *an excess* of NaO,CO_2, either to another portion of the original solution, or to the solution in which $NH_4O + NH_4O,CO_2$ has failed to produce a precipitate, and boil it in a test-tube. (Observ. *o*.)

White, immediately soluble in NH_4Cl.

MgO.

Heat also a portion of this precipitate, or of that produced by $\widetilde{(2NaO,)HO,PhO_5}$ upon charcoal before the blow-pipe, then moisten the little mass with CoO,NO_5, and heat it again strongly before the blow-pipe.

Faint Pink Mass.

MgO.

(See Observation *p*.)

Mg.

No precipitate or turbidness produced by either HS, or NH_4S, nor by NH_4O,CO_2.

Presence of $KO-NH_3$—NaO, or possibly LiO. (Observation *q*.)

To the solution in which $NH_4O + NH_4O,CO_2$ failed to produce a precipitate, or which re-dissolved the precipitate at first produced, add $(2NaO),HO,PhO_5$; boil and shake violently. (Observations *m*, *n*.)

O.

Presence of NH_3 — KO — NaO.

Concentrate a portion of the original solution (to which, of course, no NH_3 has been added), and mix it in a glass test-tube with a solution of caustic KO.

ODOUR of NH_3.

Presence of NH_3.

Confirm by holding a strip of moistened reddened litmus paper in the steam which issues at the mouth of the tube whilst boiling the mixture; the red litmus paper becomes

Blue.

Presence of NH_3.

Hold a glass tube, moistened with strong $\overline{A},HO$ over the mouth of the tube, or within it, after having added the solution of caustic KO, as above said.

Thick White Fumes.

NH_3.

NH_3.

5

NO ODOUR.

Presence of KO—NaO.

Neutralize a portion of the original solution (if necessary), to which no NH_3 has been added, with pure NaO,CO_2, and add thereto *an excess* of a concentrated solution of $\overline{T},2HO$, and *shake the mixture violently*. (Observations *r*, *s*, *t*.)

White Granular Precipitate.

Presence of KO.

Confirm by adding to another portion of the very concentrated original solution *with which no NH_3 has been used*, a solution of $PtCl_2$, alcohol, and a drop or two of HCl, so that it may be slightly acid.

Pale Yellow.

KO.

(See Observation *u*.)

K.

6

O.

Presence of NaO.

Confirm by evaporating a portion of the original solution to dryness, or to pasty consistence, add alcohol, and inflame it; or else heat a small portion of the residue before the blow-pipe on a platinum hook. In both cases,

Yellow Flame.

Na.

7

1 | 2 | 3 | 4

OBSERVATIONS ON TABLE VI.

GENERAL REMARKS.

a. If, on slightly supersaturating the original solution with NH_4O, a white precipitate or turbidness is produced, MgO is certainly present, since neither StO, nor BaO, nor CaO, is precipitated by this reagent, at least in solutions under present consideration. Yet MgO might be present in considerable quantity, and NH_4O produce no precipitate; this happens when the liquid contains enough acid to form, with the NH_4O added, a quantity of ammoniacal salt sufficient to prevent the precipitation of the magnesia. Wherefore, after having slightly supersaturated the solution, as just said, with NH_4O, the white precipitate or turbidness (MgO,HO) produced is at once redissolved by adding sal-ammoniac. Of course, if the original be acid, and contains phosphates, arseniates, &c., of earths, the addition of NH_4O will also produce a precipitate, but such acid solutions do not come under present consideration, and should be examined according to the directions given for the analysis of substances insoluble in water but soluble in acids. (See Observation *i.*)

b. After having added $NH_4O + NH_4Cl$ and NH_4O,CO_2 *in the cold*, a precipitate is *usually* formed if either BaO—StO—or CaO is present; but on *boiling* the liquor, the precipitate which may not have been produced *in the cold* never fails in making its appearance; yet a precipitate may be produced by boiling, *even though the solution may not contain a trace of the latter bases*, IF NH_4Cl IS NOT IN SUFFICIENT QUANTITY. In such a case, magnesia being present, a subcarbonate of magnesia ($3MgO,CO_2$)+MgO,HO—is then formed, which is, however, most readily distinguished from that caused by baryta, strontia, or lime, because subcarbonate of magnesia is immediately redissolved by adding more NH_4Cl, or often *merely by continuing the boiling*, for, gradually as the excess of ammonia is volatilized, the sal-ammoniac, eventually redissolves the subcarbonate of magnesia at first produced.

Group 1 *to* 3.

c. If the addition of CaO,SO_3 determine at once a heavy white precipitate, the presence of BaO is very probable, since the production of the precipitate by strontia, in such circumstances, takes a longer time to appear.

d. If the solution contain *oxalic acid*, the addition of sulphate of lime will, of course, produce a precipitate of oxalate of lime, which may be mistaken for one of sulphate of baryta, or even of strontia. If, therefore, a precipitate be obtained by CaO,SO_3, the operator will do well to test another portion with dilute SO_3, or a soluble sulphate (NaO,SO_3, for example), which, if baryta is present, will, of course, produce a white precipitate. Confirm, besides, by the tests mentioned in this column. (See Observation *f.*)

e. It is advisable to concentrate the original solution to be tested by $SiFl_2$,HFl, in order to expedite the formation of the precipitate, which otherwise would require a long time to be produced; and it is absolutely necessary that the solution so tested should be acid, or at most quite neutral, for an excess of base would produce an abundant deposit of silica.

f. Take care to use the bichromate ($KO,2CrO_3$), and not the neutral chromate (KO,CrO_3), for the former produces a precipitate in salts of baryta, but not in those of strontia, whilst the latter produces a precipitate in both, and is accordingly confirmatory of the presence of baryta only when other tests have shown the absence of strontia. See also TABLE X., Observation *c.*

g. (Col. 1.) It is needless to look for AsO_5—AsO_3—BO_3—CO_2—SiO_3—SO_3—$\overline{O}$,HO—if Ba is present.

h. (Col. 2.) It is needless to look for AsO_5—AsO_3—BO_3—CO_2—SiO_3—Fl or HFl—$\overline{O}$,HO if St is present.

i. (Col. 3) If lime exist in the compound in the state of an acid arseniate, or phosphate, or borate, &c., the attempt at neutralizing the original solution (which in such a case must have been acid, and therefore scarcely comes under this table) with NH_4O, will produce a white precipitate. In order to prove that lime is present, a portion of the original solution may be mixed with alcohol, and dilute sulphuric acid being then added, a white precipitate of sulphate of lime will be produced.

j. As oxalate of ammonia ($NH_4O,\overline{O}$) produces also a white precipitate ($StO,\overline{O}$) in neutral baryta and strontia solutions, the absence of these bases must, of course, be ascertained before concluding that the precipitate produced by $NH_4O,\overline{O}$ is due to the presence of lime.

k. It is well that the operator should bear in mind that oxalate of ammonia, ($NH_4O,\overline{O}$) or, in fact, any other soluble oxalate and oxalic acid, produce also a white pulverulent precipitate (MgO,O) even in presence of ammoniacal salts, when *boiled* with solutions of magnesia. Yet this precipitate does not take place immediately, but only when the mixture has boiled for a short time. In the cold, no precipitate is produced in magnesian solutions by $NH_4O,\overline{O}$.

l. It is needless to look for AsO_5—AsO_3—BO_3—CO_2—PhO_5—Fl or HFl—$\overline{O}$,HO and scarcely for SO_3, if Ca is present, unless the original solution is *acid*, but in that case it does not properly come under the present table.

Group 4.

m. The solution to be tested for MgO by $\overline{(2NaO)HO,PhO_5}$ should not be too dilute, since in such a case no precipitate would be formed; yet by boiling, a precipitate is always produced, which does not disappear on cooling. The presence of a pretty large proportion of ammoniacal salt does not interfere with the formation of that precipitate. Yet if the quantity of ammoniacal salt present be very large, the precipitate does not appear, except after violent shaking for five or six minutes.

n. (Col. 4.) The absence of baryta, strontia, and lime, must of course be strictly ascertained before ascribing the white precipitate produced by $\overline{(2NaO)HO,PhO_5}$ to the presence of magnesia, since that reagent produces a white precipitate with the above and other bases.

o. In confirming the presence of MgO, by adding NaO,CO_2 to the solution, take care, if ammoniacal salt be present, to use a pretty large excess of NaO,CO_2, for unless this precaution be taken, no precipitate will be produced; but as soon as the ammoniacal salt is decomposed by the excess of NaO,CO_2, the white precipitate makes its appearance.

p. It is needless to look for AsO_5—AsO_3—BO_3—CO_2—Fl or HFl—$\overline{O}$,HO—SiO_3, if Mg is present.

Group 5 *to* 7.

q. LiO being a scarce substance is not likely to be present, its detection, however, is indicated in the Supplementary Tables.

r. (Col. 6.) Shaking or stirring has always a great influence on chemical affinities, but in this instance, more particularly perhaps than in any other, for tartaric acid hardly produces any precipitate in a potash solution without it, and the solution of $\overline{T}$,2HO must be concentrated, *and in excess*, or else no precipitate will be produced. It is also necessary, sometimes, to add a little alcohol, in which bitartrate of potash is much less soluble than in water. All the precipitates which the salts of potash form with the various reagents being soluble in a large quantity of water, the solution operated upon should always be concentrated. *

s. If the concentrated liquor to be tested with $\overline{T}$,2HO is acid, it is absolutely necessary to neutralize it with NaO,CO_2 before adding the $\overline{T}$,2HO, since $\overline{(2KO)T}$ is dissolved by the strong acids, even by $\overline{O}$,HO. If, on the contrary, the concentrated solution is alkaline, the solution of $\overline{T}$,2HO must be added in tolerably large excess, since bitartrate of potash ($KO,HO,\overline{T}$) is soluble in alkalies.

t. Take care not to mistake for tartrate of potash, the white precipitate of *sulphur*, which may be produced by $\overline{T}$,2HO in certain solutions, for example, in that of a soluble hyposulphite.

u. If the solution under examination is one of IODIDE OF POTASSIUM, $PtCl_2$, instead of producing the granular yellow precipitate, which is characteristic of the presence of potash, it yields a dark purple colour.

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* *r.* It is important that the solution in question should contain no ammonia, or ammoniacal salts, since these compounds behave like KO with bichloride of platinum, sulphate of alumina, and even sometimes with $\overline{T}$,2HO.

TABLE VII.

Systematic Analysis of Compounds which are SOLUBLE IN WATER, and which are supposed to consist only of ONE ACID and ONE BASE, or ONE METAL and ONE NON-METALLIC BODY.

If the examination for bases has shown the presence of metallic oxydes, it is best to remove them by HS and by NH_4S before testing for acids. Concentrate by heat (if necessary) a portion of the solution of the substance under examination, add thereto some HCl, and boil. (Observations *a*, *b*, *c*.) Or, if the substance be in the solid state, pulverize it, if necessary (Observation *d*), and dissolve about fifty grains of it in about one fluid ounce of pure distilled HO. To a small portion of that solution add some concentrated HCl, and boil. (See Observations *a*, *b*, *c*.)

EFFERVESCENCE.

Presence of CO_2—HS—SO_2—Cy. (See Observations *e* to *i*, in TABLE I.—E.)

NO ODOUR.

CO_2. Take a fresh portion of the original solution, put it into a small flask provided with a perforated cork and a bent tube, plunging into lime-water, pour HCl through the funnel A,

and if a

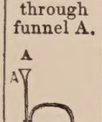
White Precipitate

is produced in beaker B, presence of CO_2. (Observation *e*.)

CO_2.

ODOUR of HS.

Sulphuret. Take another portion of the original solution, put it into a small flask provided with a perforated cork and a bent tube, plunging into a solution of PbO,A, in beaker B, pour HCl through funnel A.



If a

Black. Ppte.

appears in B, presence of HS. (Observation *e*.)

HS.

ODOUR of SO_2.

But NO milkiness nor yellow precipitate.

Milkiness or **Yellow Precipitate of S.**

SO_2. | S_2O_2.

Take another portion of the concentrated solution of the compound, add thereto some SO_3HO, and boil.

Odour of SO_2.

(Observation *f*.) Take a solution of green manganate of potash, and add thereto some dilute SO_3, which immediately turns it purple red. To this purple red liquor add a portion of the original aqueous solution to which no HCl has been added. (Obs. *g*.) If the red purple liquor is thereby

Decolourized,

SO_2 or S_2O_2. test another portion of the original aqueous solution, to which no HCl has been added, with AgO,NO_5.

White. SO_2. (Observations *h*, *i*.)

White. **Brown.** **Black.** S_2O_2. (Observation *h*.)

SO_2. | S_2O_2.

ODOUR of Cy.

Cyanide of alkali or of earth. If the solution, by boiling with HCl, remains

Colourless,

go for the appropriate tests as directed from Cols. 6 to 26, and particularly Col. 20.

NO EFFERVESCENCE. (Observations *e* to *i*, in TABLE I.—E., and Observation *i* of this TABLE.)

ODOUR of Cy.

Presence of Cyanides, Ferrocyanides, Ferricyanides, of alkalies or of earths. (Observation *j*.) The solution, by boiling with HCl,

Remains **Colourless.** Cyanide. Proceed with the original solution as directed from Cols. 6, to 26, and especially as at Col. 20.

Becomes **Blue.** Ferrocyanide. **Dark Green.** Ferricyanide.

To another portion of the original solution add AgO,NO_5.

White. Insoluble. **Reddish Brown.** Dissolves.

Add to the solution containing the precipitate an excess of NH_3.

Insoluble. Boil the whole. **Drab.** H_2Cy_3Fe.

Dissolves. **Brown.** $H_3Cy_6Fe_2$.

If no other base than one of the alkalies, or lime, or magnesia, or if no bases at all have been found, add solution of SO_2 to a portion of the original solution, apply heat, and then pass a stream of HS (Observations *k*, *l*, *m*) through it. If this produces a ppte.

Greenish. Cr_2O_3. to that greenish solution add an excess of NH_3, if it produces a

Greenish Precipitate. Cr_2O_3. To another portion of the original solution add PbO,A.

Yellow. Cr_2O_3. Take a minute portion of this precipitate and fuse it with borax before the blowpipe, on a hook of platinum wire.

Emerald Green. Cr_2O_3.

H_2Cy_3Fe. | $H_3Cy_6Fe_2$. | Cr_2O_3.

Yellow. AsO_3—AsO_5. Take a fresh portion of the original solution, to which no HCl has been added, (Observation *n*) and then add some AgO,NO_5, and afterwards, carefully, some NH_3, drop by drop, until the liquor is nearly neutral, but has still a very slight acid reaction.

Lemon Yellow. AsO_3. | **Light Brown.** AsO_5.

AsO_3. | AsO_5.

Take another portion of the *concentrated* original solution, neutralize it, if necessary, by NH_3 (Observation *o*) if it have an acid reaction, or by NO_5 if it have an alkaline reaction (Observation *p*), and pour into it a solution of BaCl (Observation *q*).

A Precipitate is produced.

Presence of SO_3.—SiO_3.—Fl.—$\overline{O}$,HO.—PhO_5,3HO.—BO_3. (Also CO_2—CrO_3—AsO_3—AsO_5—SO_2.—See Observ. *r*.) Add to the liquor containing the precipitate which has been just produced by BaCl, *an excess* of HCl, and apply heat.

Precipitate remains **INSOLUBLE.** Add a large quantity of water.

Insoluble. Presence of SO_3. (Observations *s*, *t*.)

The Precipitate is REDISSOLVED.

Evaporate a fresh portion of the original solution, previously acidified, to perfect dryness. Drench the dry residue with concentrated HCl, and, after about a quarter of an hour's digestion add water, if a gritty, insoluble

White Powder

is left, presence of SiO_3. Confirm by fusion with NaO,CO_2 before blowpipe. (See Dictionary.)

SiO_3.

Neutralize with NH_3 the excess of HCl employed to redissolve the precipitate produced by BaCl (or if a portion of the original solution be employed, add an excess of sal ammoniac (NH_4Cl), neutralize with NH_3 if necessary) and add a few drops of CaCl. (Observation *u*.)

White Precipitate.

Presence of Fl.—$\overline{O}$,HO.—PhO_5,3HO. (And possibly BO_3. See Observat. *v*., and also IO_5—BrO_5—PhO_5.) To this liquor containing the precipitate add excess of $\overline{A}$,HO.

Precipitate remains Insoluble. Fl.—$\overline{O}$,HO. Digest the insoluble precipitate in HCl.

Remains Insoluble. Fl. Put a portion of this precipitate (or of the original substance, well-pulverized) into a platinum crucible, pour concentrated SO_3 upon it and cover the whole with a glass plate coated with wax and bearing tracings.

Corrosion. (See Observ. *w*.)

Fl.

Dissolves. $\overline{O}$,HO. Add excess of NH_3, and boil.

White Precipitate. Confirm by heating a portion of the precipitate, previously dried, with SO_3 in a test-tube, and inflame the gas evolved.

Blue Flame. (See Observ. *x*.)

$\overline{O}$,HO.

Ppte. Dissolves. $PhO_5$3HO. Supersaturate this same liquor with NH_3.

White Precipitate reproduced. PhO_5. Confirm by adding to a fresh portion of the original solution, to which no HCl has been added (Obs. *y*), some AgO,NO_5, and then carefully add dilute NH_3 until perfect neutralization.

Yellow. (Observation *z*.)

PhO_5.

O. Presence of BO_3. Evaporate a portion of the original solution to dryness in a small capsule (or take at once a portion of the substance, if it be in the solid state), moisten it with a few drops of concentrated SO_3, pour some alcohol upon it, warm the capsule gently, and inflame the vapour.

Green Flame. (See Observation *a'*.) and TABLE XXII. Observation *b*.

BO_3.

NO Precipitate is produced. (Observations *q*—*b'*.)

Take another portion of the original solution, to which no HCl has been added, pour into it *an excess* of NO_5, and then test it with AgO,NO_5. (Observations *c'*, *d'*.)

Black. Presence of a sulphuret, or of HS. (See Observation *e'*.)

Sulphuret.

Becoming **Black.** S_2O_2. (See Col. 3.) (Observation *f'*.)

S_2O_2.

White,

or White with a Tinge of Yellow.

Presence of $\overline{O}$,HO—Cl—HCl or Chlorides.—I—HI or Iodides—HCy or Cyanides.—CyS—Br—HBr or Bromides. (Observat. *g'*.) Possibly Bromates. (See Observat. *h'*.) Add to the liquor containing the precipitate produced by AgO,NO_5 an excess of NH_3, but gradually, and shaking after each addition. Apply heat if necessary. (Observation *i'*.)

The Precipitate is Redissolved.

Cl.—HCl.—Br.—HBr—BrO_5.—HCy. If the precipitate is *at once* dissolved by the NH_3, presence of HCl or Chloride, but if not at once dissolved, or if heat must be applied, the precipitate is probably a bromate, a bromide, or a cyanide (Observation *i'*.)

The Precipitate is Insoluble.

HI or Iodides, CyS or Sulphocyanides.

Take a portion of the original solution. add solution of KO, then some FeO,SO_3 and a slight excess of HCl.

Blue. (Observ. *d'*—*k'*.) Confirm by adding HCl to the original solution, and putting a drop of NH_4S_5 into a small capsule, put the whole under a glass jar or bell, after about ten minutes remove the capsule containing NH_4S_5 and test it with Fe_2Cl_3.

Blood Red Colour. (See Obs. *j'*—*k'*.)

HCy.

No Blue Ppte. Evaporate a portion of the original solution to dryness, and expose a portion of the dry residue with microcosmic salt to the smallest possible flame of a spirit lamp, and on the hook of a brass wire.

Blue Flame. (See Observ. *l'*.)

HCl.

Take another portion of the concentrated original solution acidified, or that containing the precipitate produced by AgO,NO_5, pass through it a few bubbles of Cl gas, or add an aqueous solution of Cl, add then, enough ether to form a layer about one-eighth of an inch thick floating over the liquor, cork the tube containing the mixture well, and, having shaken the whole violently, leave it at rest. If, after a few minutes, the ether floating at the top has a

Hyacinth Red, or Reddish Yellow, Colour,

(Observation *m'*.) Presence of Br.—Confirm by transferring the ethereal solution to a glass test-tube, add thereto solution of KO, *which decolourizes the liquid*, evaporate to dryness, to the dry residue add some MnO_2, and then some concentrated SO_3, close the tube with a cork provided with a bent tube, plunging into another test-tube containing aqueous solution of starch. (Observat. *n'*.) If the fumes in the first test-tube are

Hyacinth Red Fumes,

and if the solution of starch turns

Yellow,

Presence of Bromate or Bromide. Take a portion of the precipitate produced by AgO,NO_5, dry it, pulverize it, and mix it with a small quantity of pulverized charcoal, put the mixture in a test-tube and apply heat. (Observation *o'*.)

Deflagration. BrO_5. | O. HBr.

To a portion of the original solution add aqueous solution of starch, and a few drops of NO_5.

Blue. Presence of I. (Observ. *p'*.) Confirm by evaporating a portion of the original solution to dryness, pour concentrated SO_3 on the dry residue and apply heat.

Violet Fumes. I.

HI.

To another portion of the original solution, acidified with HCl, add an excess of Fe_2Cl_3.

Blood Red Colour. Presence of CyS. Add to this blood red solution one of corrosive sublimate.

Decolorized.

CyS.

O. (Observation *d'*.) Presence of NO_5.—ClO_5. Possibly HgCy. Possibly, also, $\overline{O}$,HO—PhO_5,3HO.—BO_3. (See Observ. *q'*, *r'*.)

To a portion of the original solution add a piece of metallic iron, and then an excess of HCl (odour of HCy generally evolved) after a few minutes add solution of KO, and then supersaturate the KO with HCl

Blue. Or, better still, to a portion of the original solution add HCl, put a drop of NH_4S_5 into a small capsule, put the whole under a glass bell, and after about ten minutes remove the capsule containing NH_4S_5 and add thereto a few drops of Fe_2Cl_3.

Blood Red. Colour. HgCy. (See Ob. *j*, *k*, *r'*.)

HCy.

Take a portion of the original solution in HCl, add thereto about one fourth of its bulk of concentrated SO_3, and drop into it a small crystal of FeO,SO_3, the crystal becomes

Greenish Black Colour. Presence of NO_5. (See Observ. *s'*.) Confirm by taking another portion of the original solution, add thereto about one fourth of its bulk of concentrated SO_3 and a few copper turnings; apply heat if necessary.

Ruddy Fumes. NO_5. (Observ. *t'*—*w'*.)

NO_5.

To a small portion of the concentrated original solution add about half its bulk of concentrated SO_3.

Yellow Liquor. Greenish Yellow Fumes. Accompanied by a peculiar odour, somewhat like Cl. (Observ. *v'*.) Presence of ClO_5. Confirm by mixing a portion of the solid compound (or a portion of the dry residue left by evaporating some of the original solution to dryness) with microcosmic salt, and expose it, on the hook of a brass wire to the smallest possible flame of a spirit-lamp.

Blue Flame. ClO5. (Obs. *w'*.)

ClO_5.

OBSERVATIONS ON TABLE VII.

Group 1 *to* 5.

a. If a benzoate is present, this addition of HCl may cause a white precipitate, since benzoates are decomposed by acids, the benzoic acid being thereby precipitated.

b. Remember that, if the solution contains Hg_2O—AgO or PbO, this addition of HCl will produce a white precipitate, as will have been already seen when testing for bases (see Table IV.). In such a case, and although the presence of these bases may not interfere much, or even at all, with the subsequent tests, it is best to remove them at once by passing a stream of HS through the original liquor to supersaturation, filtering, and then proceeding with the analysis, as directed in the Table. Hg_2O and AgO, however, may be completely removed by HCl alone.

c. If a hyposulphite is present, a yellowish-white precipitate will be produced by HCl, which precipitate is S, and an evolution of SO_2, recognizable by its odour, takes place at the same time. If there be any doubt as to the odour of SO_2, it will be well to treat a fresh portion of the solution with SO_3, and boil. If a *hyposulphite* is present, the precipitate is white only at first, for it soon becomes of a pale or lemon-yellow colour, and consists of sulphur. (See Table IV., Col. 4.)

d. If the substance is very soluble in water, it is evidently unnecessary to pulverize it. I have given elsewhere a list of the acids which form insoluble salts with such bases; the attention of the operator should therefore be now directed to the acids which can form a salt soluble in water with the base that may have been found by the preceding investigation.

e. (Cols. 1, 2.) If the substance is a carbonate, or a sulphuret, it will have been detected at the onset. (See the observations on Cols. 1 to 4, Table IV.)

f. (Cols. 3, 4.) Sulphites are always decomposed by strong HCl, or by moderately strong SO_3, but the effervescence produced by the disengagement of the SO_2, is not always observable unless the solution is concentrated. Whether an effervescence takes place or not, a characteristic odour of SO_2, which is that of burning sulphur, is always evolved, especially by boiling, and infallibly when SO_3 is used instead of HCl.

g. The solution of green manganate of potash mentioned may be instantly prepared by fusing, over a spirit-lamp, in a glass test-tube, a small quantity of peroxyde of manganese, nitrate of potash, and a small fragment of caustic potash; the whole on fusing forms a green mass which, dissolved in water, after it has cooled, forms the solution of the green manganate wanted. Dilute SO_3 is then poured into this solution until it turns red, and if the original aqueous solution under examination, being poured into the red liquor, immediately decolourizes it, SO_2 or S_2O_2 is present. The aqueous solution *should not contain muriatic acid*, since manganate of potash is decomposed and decolourized by HCl, even in the cold.

h. The principal distinctive character between sulphites and hyposulphites is, that when the latter are present, the odour of SO_2 is accompanied by a yellow deposit of sulphur. The precipitate produced by AgO,NO_5 in solutions of sulphites is soluble in a large excess of solution of alkaline sulphite, and turns brownish or black by boiling, owing to a reduction of the metal; the liquor contains then sulphuric acid. The reaction is as follows: $AgO,SO_2 = Ag + SO_3$. With hyposulphites, the precipitate produced by AgO,NO_5 is white, and soon becomes brown, and then black, in the cold, which effect is due to the production of sulphuret of silver, thus:

$$AgO,NO_5 + NaO,S_2O_2 = AgS + NaO,SO_3 + NO_5.$$

i. Bear in mind that, although sulphites are always decomposed by HCl, and especially by SO_3,HO (Obs. *c.*), with evolution of SO_2, yet that evolution of gas is not always accompanied by a visible effervescence Therefore, take care, before concluding to the absence of SO_2, to apply heat after having added SO_3 to the pulverized compound, or to its solution, and to smell the liquor whilst thus hot.

Group 6 *to* 11.

j. (Cols. 6 to 8.) The cyanides of the alkaline and earthy metals are all soluble in water, and have a strongly alkaline reaction; all, or nearly all, other cyanides are insoluble in water. Cyanide of gold, and of mercury, dissolve in that menstruum. The aqueous solutions of ferro-cyanides are always, more or less, of a yellow colour, are neutral to test-papers, and have no odour previous to the treatment with HCl.

k. (Cols. 9, 10, 11.) In the examination of the substances for bases, the presence of chromic, arsenious, and arsenic acids will probably have been detected at the onset, when passing a stream of HS through the solution; for if chromic acid was present, the liquor which had a yellow, yellowish-green, or orange-red colour, will have become green, or will have deposited a greenish precipitate, owing to the reduction of chromic acid to the state of oxyde of chromium (see Table IV., Col. 6), whilst arsenious and arsenic acids will have produced a yellow precipitate, under the influence of HS. (See Table IV., Cols. 17, 18.)

l. The addition of a solution of SO_2 converts AsO_5 into AsO_3, which is much more easily precipitated by HS. If chromic acid is present, it is at once reduced by SO_2 to the state of chromic oxyde (Cr_2O_3), so that the liquor becomes green.

m. It is evident that if another base than the alkalies, lime, or magnesia, has been found, it will be useless to look for either arsenic, arsenious, or chromic acids, since no other arseniates or arsenites are soluble in water than the arseniates or arsenites of alkalies, and the only salts of chromic acid soluble in water are the chromates of alkalies, chromate of lime, and chromate of magnesia.

n. (Cols. 10, 11.) In testing for the acids of arsenic by AgO,NO_5, the operator is recommended to use a solution which contains no HCl, or to which no HCl has been added, because the addition of AgO,NO_5 to such a solution would of course produce at once a curdy precipitate of AgCl. Should he, however, have added by accident HCl to the liquor, or should he have no other solution left than that to which he may have added that acid, he may nevertheless test it for arsenic by adding more AgO,NO_5 than is necessary to precipitate all the chlorine, that is to say, by adding AgO,NO_5 to the liquor until it ceases to produce either precipitate or turbidness, boiling the liquor for a few moments, so as to agglomerate well the curdy precipitate, filtering, and pouring into the filtrate a few drops more of AgO,NO_5 to make sure that no turbidness is thereby any longer produced, and that an excess of AgO,NO_5 is present. If the clear filtrate be now nearly neutralized by NH_3, as described in the Table, the characteristic reaction there mentioned will be produced if an acid of arsenic is present.

Group 12 *to* 28.

o. The neutralizing of the acid liquor with NH_3 may produce a precipitate, as we already remarked in Observations *c*, *d*, on Table V. But if the operator have complied with the direction given at the beginning of the present table, and separated all the bases which may be present by treatment with HS and with NH_4S, this difficulty will not present itself; and moreover, if the original solution was acid, the table for acid solutions should be consulted.

p. The solution must evidently be either neutral, acid, or alkaline; but remember that a liquor may have an acid, or an alkaline reaction, and yet contain only a neutral salt, that is, a salt consisting of one equivalent of acid, and one equivalent of base.

An acid reaction indicates either the presence of a free acid, or of an acid salt, or of a neutral salt of the heavy metallic oxydes. An alkaline reaction indicates the presence of a free alkali, or of a basic, or neutral alkaline carbonate, or of a free alkaline earth, or a substance soluble in an alkaline liquid. If the solution have an acid reaction, pour into it a drop or two of *very dilute* NH_3. If this shows a tendency to produce a precipitate, it is useless to add any more, for it is a sign that the liquor is an aqueous solution of a neutral salt of one of the heavy metallic oxydes, or of an arseniate or perphosphate of earths. If this addition of a drop or two of very dilute NH produces no precipitate, then the liquor contains either a free acid, or an acid salt; more NH_3, therefore, should be added to it, until it is rendered neutral to litmus-paper; but if a tendency to precipitate is observed before that point is reached, the operator should stop, as it shows that the solution contains probably an acid salt of an oxyde, which can be precipitated by NH_3.

If the liquor under examination is alkaline, dilute NO_5 should be added until it becomes neutral to litmus-paper, and if, in the subsequent course of analysis, no other acid than NO_5 is detected, then a fresh portion of the original liquor should be neutralized with dilute SO_3, and tested for NO_5.

If the liquor under examination is neutral to litmus-paper, nothing, of course, is to be done than to proceed with the analysis.

If a base, or metallic oxyde, or metallic acid has been detected in the preceding examination, it is best to remove it at once, either by HS or by NH_4S, as the case may be, that is, according to the nature of the base, as mentioned in the general rules, and then the analysis proceeds as directed. Only in such a case, the operator will remember that if the original liquor was acid, and contained an earthy phosphate, arseniate, oxalate, &c., no phosphoric acid will be found in the filtered liquor. This, however, is of no consequence, since phosphoric and the other acids will have been detected whilst looking for the bases in Table V.

q. It is necessary to concentrate the liquor under examination, because borate of baryta (BaO,BO_3) is completely soluble in a large quantity of water.

Take care not to pour too much BaCl in the liquor, because borate of baryta (BaO,BO_3) is soluble in an excess of chloride of barium.

The liquor must not contain much ammoniacal salts, because these salts interfere with the precipitation of borates by BaCl.

Group 12 *to* 17.

r. AsO_5,—AsO_3,—SO_2, and CrO_3, will have been detected, as shown in Cols. 3 and 9 to 11. The precipitate produced by BaCl, in solutions containing chromic acid, is yellow.

s. (Col. 12.) The precipitate produced by BaCl must be treated by a large quantity of water, in order to see whether it will dissolve therein, for in a concentrated liquid which contains an excess of HCl, the reagent, BaCl, will produce a precipitate of BaCl, which, being less soluble in acids than in water, may simulate a precipitate of BaO,SO_3, and, consequently, erroneously lead the operator to believe that SO_3 is present. But, by adding a large proportion of water, the precipitate produced by BaCl will dissolve, which behaviour distinguishes the precipitate at once from that of BaO,SO_3, which is perfectly insoluble both in acids and in water.

t. It frequently happens that sulphites are contaminated by sulphates, and yield accordingly a milkiness, or a scanty precipitate, insoluble in water, when their solutions are tested by BaCl; in such cases the scantiness of the precipitate shows that the sulphuric acid is only an accidental impurity.

u. Carbonic, sulphurous, arsenic, arsenious, and chromic acids are also precipitated by CaCl in neutral or alkaline solutions, but as these acids will have been detected before, according to the directions given in Cols. 1 to 11, they need not be otherwise taken notice of here.

Group 14 *to* 17.

v. If the liquor does not contain enough sal-ammoniac, the addition of CaCl will produce a white precipitate of CaO,BO_3, if boracic acid or a borate is present; but if enough sal-ammoniac have been formed or added, no precipitate will be produced by CaCl, since ammoniacal salts prevent the precipitation of borate of lime, or dissolve it; borate of lime is soluble also in excess of CaCl, and water takes it up more readily than borate of barytes.

If, instead of using a fresh portion of the original solution, the operator merely neutralizes with NH the HCl employed to redissolve the precipitate produced by BaCl, the white precipitate first obtained may of course be reproduced.

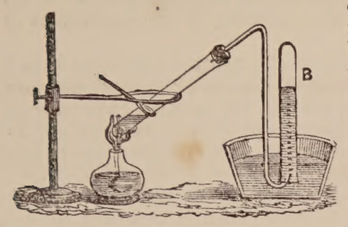
w. (Col. 14.) If a fluoride is present, the precipitate produced by CaCl is so transparent that it can hardly be seen, and does not settle well, except NH_3 be further added, which then produces a very bulky precipitate.

The best way of obtaining the characteristic reaction of hydrofluoric acid (HFl) upon glass, consists in coating the piece of glass with a film of bees'-wax, which is done by heating the glass, and then rubbing bees'-wax upon it. When cold, lines or writing are to be traced upon it with a pointed brass wire, a pin for example, or pointed piece of hard wood, or of ivory, taking care that the point penetrates through the wax so as to leave the glass bare at that part. The substance to be examined, and previously reduced to powder if necessary, is then put into a platinum crucible, concentrated SO_3,HO is poured upon it, and the whole is covered by the piece of glass, with the tracing downwards, of course; the crucible is then gently and carefully heated by means of a spirit-lamp, so as not to fuse the wax; and further, to guard against such an occurrence, some water should be poured upon the back of the glass-plate to keep it cool. It is absolutely necessary to apply a gentle heat, especially if the experiment is performed with the precipitate (CaFl) obtained, because, in *the cold*, the fluoride of calcium operated upon, only forms a viscid liquid, from which no HFl is evolved. The wax is next removed by heating the glass, and wiping it off, and then washing the plate with essence of turpentine. If only a trace of HFl was present, the tracing cannot be seen except by breathing upon the glass, after having removed the wax.

x. (Col. 15.) If the substance under examination is in the solid state, the operator has only to pulverize it, mix it with an excess of concentrated SO_3,HO, and after applying heat he may succeed in inflaming the gas which escapes, and which is a mixture of carbonic acid (CO_2) and carbonic oxyde (CO), thus:

$$\underbrace{C_2O_3}_{\text{Oxalic acid.}} = CO_2 + CO.$$

When the quantity under examination is small, the carbonic acid, and the aqueous, or acid steam evolved at the same time, interfere with the inflaming of the gas. It is, therefore, much better, whether the substance is in the solid, or in the liquid state, to transfer a portion of it (which, if in the liquid state, should be very concentrated) to a sufficiently large glass test-tube, or small flask provided with a perforated cork, and having added the concentrated sulphuric acid, and applied heat, to collect into the tube B (see fig. in margin) the gas thus evolved, and which may then be readily inflamed. When the substance to be examined, as just said, is a liquid, not only should it be very concentrated, but the operator should also defer collecting the gas until the disengagement in the tube becomes manifest. The burning of the gas with a blue flame is more apparent if the operator stands against day-light, and if before he inflames the gas he shakes it, with a small fragment of KO rapidly introduced into the tube closed with the thumb. After shaking, the thumb is sucked in by the absorption of the CO_2, and no other gas is then left in the tube than CO, which, on removing the thumb, may be inflamed; it then burns with a beautiful, and very characteristic blue flame. T.22.-A.O.*o*.



y. (Col. 16.) If the liquor contains HCl, add a few drops of NO_5, and then an excess of AgO,NO_5, that is, until this reagent no longer produces a white precipitate (AgCl) ; boil, filter, test the filtrate again with AgO,NO_5 to make sure that it no longer produces a white precipitate, and that the liquor contains an excess of the reagent, and then add carefully some dilute NH_3, until the liquor is very nearly neutralized, when a characteristic yellow precipitate (PhO_5)3AgO) will be produced. It is important not to add more NH_3 than is absolutely necessary very nearly to neutralize the liquor, since the yellow precipitate of phosphate of silver is immediately redissolved, or is not produced, if there be the slightest excess of either NH_3 or of acid. If, however, the operator has accidentally added more NH_3 than needful, he may neutralize it with a little dilute NO_5, and *vice versâ*.

z. The absence of SiO_3 must have been proved before testing for PhO_5 with AgO,NO_5, since the latter reagent forms, with silica, a yellow precipitate of silicate of silver, soluble in dilute NO_5. *

a'. (Col. 17.) The colour of the flame is more distinct at the edges, and a very minute quantity of boracic acid may be rendered apparent by inflaming the alcohol, extinguishing the flame, and rekindling it. This *modus operandi* increases much the delicacy of the test. See also Table XXII.—A., Observation *b*.

Group 18 *to* 28.

b'. If the solution contains much sal-ammoniac, or is too dilute, the addition of BaCl will have failed in producing a precipitate, even though boracic, or oxalic acid, or a borate, or oxalate, may be present, since both these acids, and their salts, form, with baryta, a precipitate which is soluble in solutions of salts of ammonia.

c'. And, forasmuch as borate, oxalate, and phosphate of silver are soluble in an excess of NO_5, the addition of AgO,NO_5 to the solution containing an excess of NO_5, would not produce a precipitate. AgO,NO_5, however, always produces a precipitate in solution of oxalic acid, or of oxalates, unless a pretty large excess of NO_5 is present. Nitrate of silver produces also a yellow precipitate (PhO_5,3AgO) in solution of phosphoric acid, or of phosphates *merely acidified* with NO_5, wherefore a decided excess of NO_5 should be used; but considering, as I said before, that oxalate, phosphate, and borate of silver are soluble both in excess of NO_5 and of NH_3, and consequently might fail in being detected by AgO,NO_5, it is advisable, before going further, to test the solution with CaCl, according to the directions given in Cols. 15 to 17.

d'. The operator must recollect that cyanide of mercury (HgCy), though soluble in water, is not precipitated by AgO,NO_5, nor, in fact, is it affected in the wet way, by any of the reagents (except the hydrosulphuret of ammonium test) by which the presence of cyanogen is usually detected, unless special treatment be resorted to. If, therefore, AgO,NO_5 at this stage of the process fails in producing a precipitate, or causes only a turbidness, he should treat the solution with hydrosulphuret of ammonium and HCl, as mentioned in Col. 20 of this Table, or he may treat it with metallic iron, HCl, and potash, as mentioned in the tests for HCy, to which he is referred. (See Dictionary.) The addition of HCl almost invariably renders the odour of HCy perceptible. (See Obs. *r'*.)

e'. (Col. 18.) If the solution contains a sulphuret, it will have been detected by the odour of HS, which will have been evolved by supersaturating a portion of the solution with HCl. (See Col. 2.)

f'. (Col. 19.) If a hyposulphite is present it will have been detected in Col. 4, the distinctive character from sulphates and sulphites being the *deposit of sulphur*, accompanied by odour of SO_2 when treated by an acid.

Groups 20 *to* 25.

g'. AgO,NO_5 produces a white precipitate with cyanides, chlorides, and bromides, but cyanide of silver is distinguished from all others, because, after drying it at a very gentle heat, it is sufficient to expose it to a red heat in a glass tube, to disengage cyanogen gas, which, being inflamed, burns with a characteristic peach-blossom flame.

h'. Bromates and bromic acid are precipitated by BaCl in the state of bromate of barytes, but as this salt is slightly soluble in water, it may, of course, exist in the solution under examination.

i'. If a ferro-cyanide is present, the precipitate produced by AgO,NO_5 will be white; but NH_3 will fail in dissolving it, and if heat is applied, the liquor becomes reddish-brown, and if boiled, a precipitate of a darker brown colour is produced. If a ferri-cyanide is present, AgO,NO_5 will produce a reddish-brown precipitate (similar to that produced by NH_3 with Fe_2O_3), which NH_3 will redissolve in the cold, but which is reprecipitated of a drab colour by boiling.

j'. (Col. 20.) The best way, perhaps, of applying this test for hydrocyanic acid is as follows : Pour into a small capsule a certain quantity of hydrosulphuret of ammonia, containing as much sulphur as it can dissolve, and empty it again, as it is sufficient that the little capsule should be moistened with this reagent. Pour into another capsule a portion of the original solution, and add thereto a slight excess of HCl. Put now the two small capsules by each other's side under a small glass bell, or inverted beaker, and leave the whole undisturbed for five or six minutes; on removing the jar, a powerful smell of HCy will generally be observed, and if now a drop of Fe_2Cl_3 be poured into the small capsule which has been moistened with NH_4S_5, an intense blood-red coloured liquid will be obtained, owing to the production of sulpho-cyanide of iron. This is, perhaps, the most positive, and it certainly is the most delicate, test for hydrocyanic acid. It was first proposed, I believe, by Dr. A. Taylor. The blood-coloured liquor is immediately decolourized by solution of corrosive sublimate, a reaction which distinguishes it from meconic acid, which produces also a blood red colour when treated by a persalt of iron, but which is not decolourized by corrosive sublimate.

k'. If the presence of cyanogen or hydrocyanic acid has been detected, the operator will do well to test a portion of the original solution at once with a per-salt of iron and with a proto-salt of copper; if the first produces a deep BLUE precipitate, and the second a chocolate-brown or crimson-red precipitate, according to the state of dilution of the liquor, a ferro-cyanide of alkali is present. If another portion of the original solution, being at once tested with a solution of a *proto-salt* of iron, produces a DEEP BLUE precipitate, a ferri-cyanide of alkali is present.

l'. (Col. 21.) The distinctive character of chlorides is, being precipitated by AgO,NO_5; the precipitated AgCl is insoluble in water and in acids, but is *immediately* dissolved by the slightest excess of ammonia, and is reprecipitated by NO_5, if, however, a very large quantity of ammoniacal salt is present, the precipitate is not so immediately reproduced. If the quantity of HCl, or of a soluble chloride is very small, AgO,NO_5 gives the liquor an opaline, or milky hue, but no precipitate; a drop of free ammonia is then sufficient to render the liquid perfectly clear.

Groups 22, 23.

m'. This yellowish-brown layer which floats at the top of the liquor is a solution of Br in ether. If the quantity of bromine is very small, this layer of ether will only have a yellowish colour. On that account, if the original solution is operated upon, it is better to pour into the liquor under examination a few drops of a solution of chlorine in water, than to pass directly a stream of chlorine in the liquor, since chlorine gas, by dissolving in it, might impart a yellowish tinge, which would simulate the presence of bromine. If, on the contrary, it is the liquid containing the precipitate caused by AgO,NO_5 which is operated upon, it is better, perhaps, to pass through it a stream of chlorine, which converts the bromide of silver into a chloride, whilst the bromine may then be extracted from the liquor by ether, as just said. In this latter case, it generally happens that the chloride of silver produced floats on the top of the liquor, but after standing for a minute or two, a slight shake of the tube is sufficient to precipitate it all to the bottom of the tube, and the layer of ether may then be distinctly seen.

n'. The most convenient way of separating the ethereal solution of bromine from the rest of the liquor is, perhaps, by means of a pipette, and in the following manner: Hold the pipette vertically, resting its small end upon a cork, or piece of caoutchouc, or upon the small finger of the left hand, so as to close the aperture, and pour into the pipette the liquor containing the ether; after a few moments the liquid will separate into two strata, the upper one, of a brown or yellowish colour, is the ethereal solution of bromine; press the tip of the fore-finger firmly upon the top (A) of the pipette, and gradually suffer the contents of the pipette to flow out until you see that the ethereal solution of bromine has descended into the narrow part (B) of the pipette; hold now the pipette over a glass test-tube, and, on entirely removing the finger, the whole of the ethereal solution of bromine will, of course, fall into it. The ethereal solution in the tube is then mixed, and shaken with as much solution of potash as will decolourize it, for which purpose a very small quantity of potash suffices, and the liquor is evaporated to dryness by means of a spirit-lamp; some peroxyde of manganese is then dropped upon the dry residue, and sulphuric acid being added, the tube is closed with a good cork, provided with a tube plunging into another test-tube, containing a solution of starch; on applying heat, and even frequently in the cold, the tube containing the mixture becomes pervaded with ruddy fumes of bromine of a characteristic odour, and these fumes, coming in contact with the starch solution in the second tube, impart immediately to it a yellow colour (bromide of starch). This colour, however, is not a very delicate test, and I think it is better to receive the fumes of bromine into a moistened tube, containing a little water at the bottom, to shake the tube, and add a small quantity of ether again, whereby the brownish layer of solution of bromine in ether can be obtained; it may be decolourized again by potash, and submitted to the usual test for bromides. (See Dictionary.)

o'. Instead of taking the precipitate produced by AgO,NO_5, it is better to evaporate a portion of the original solution to dryness at a gentle heat, to pulverize the residue with charcoal, and to heat the mixture in a glass test-tube. If a bromate is present, deflagration takes place.

Groups 24, 25.

p'. (Col. 24.) No other substance but free iodine gives a blue colour to a cold solution starch (iodide of starch), if, therefore, the original solution, tested by starch, gives a blue colour without NO_5 or Cl, it is due to the presence of *free* iodine. Chlorine decomposes iodides and hydriodic acid, and liberates iodine; NO_5 decomposes iodides and liberates iodine also; but the latter reagent, namely, NO_5, for the purpose of liberating iodine from iodides, is preferable to chlorine, since an excess of that substance prevents the blue reaction from taking place, or causes it to disappear, owing to the production of chloride of iodine, which is colourless. If the solution of starch is very weak, and there be a large quantity of iodine, the colour produced is green, and not blue.

Groups 26 *to* 28.

q'. Forasmuch as oxalate, phosphate, and borate of silver, are soluble in an excess of NO_5, it is evident that the solution now operated upon, containing an excess of NO_5, the addition of AgO,NO_5 will fail in producing a precipitate; but as these acids ($\overline{O}$,HO—PhO_5,3HO—BO_3) will have been detected before, as shown in Cols. 15, 16, 17, it is needless to dwell upon them here.

r'. (Col. 26.) But with respect to bicyanide of mercury (HgCy), although AgO,NO_5 produces a milkiness in *neutral* solutions of that compound, yet, when there is an excess of NO_5, the above reagent produces no precipitate nor milkiness; solutions of bicyanide of mercury (HgCy) treated as usual by KO, then by FeO,SO_3 and addition of HCl, evolve generally an odour of HCy, but no precipitate of Prussian blue takes place, although the liquor assumes a green colour. It is, therefore, much better to apply the sulphocyanide test, which is more delicate, and is infallible. The best way of proceeding has been given already in the observations on Col. 20, to which the reader is referred. If, however, the solution containing cyanide of mercury is treated by HS, the mercury is precipitated, and hydrocyanic acid remains in the solution, and may be identified by the formation of Prussian blue, produced by adding solution of FeO,SO_3, which has been exposed for a short time to the air, then an excess of KO, and then an excess of HCl.

s'. (Col. 27.) If the liquor is very dilute, the brown colouring produced by FeO,SO_3 takes a little time to appear, and it is often necessary to heat the liquid slightly, *but not too long*, else the colour would disappear instantly.

t'. If lead was present in the solution and has not been removed prior to testing with SO_3 + FeO,SO_3, or copper filings, the addition of SO_3 in the testing for NO_5 will produce a white precipitate (PbO,SO_3) which, however, may be totally disregarded, as it does not interfere in the least with either of the two tests, namely, FeO,SO_3 or the copper filings.

u'. *Free nitric acid* may be detected by putting a few nail or quill-scrapings into a small capsule, pouring upon them a portion of the liquid under examination, and boiling. The shavings will assume a yellow colour, which, if the nitric acid be in very small quantity, will be perceptible only at the edges. This yellow colouring is very characteristic of *free* nitric acid; even the nitrates which have an acid reaction on litmus-paper fail in producing it. (See Preliminary Examination, Table 1A., Col. 3.)

v'. (Col. 28.) If the quantity of chlorate is very small, the greenish fumes may not be perceptible, but the liquor is always coloured yellow, and a peculiar smell (chlorate of chlorous acid ClO_5,ClO_3) is evolved at the same time.

w'. The blue colour imparted to the flame of the spirit-lamp is not limited to chloric acid, all compounds containing chlorine as one of their constituents exhibit this character.—(See Preliminary Examination, Table 1A., Col. 5.)

* *z*. The yellow precipitate is tribasic phosphate of silver; the white precipitate would be bibasic phosphate of silver. (See the Dictionary, art. Phosphoric Acid.)

TABLE VIII.

Systematic Analysis of Compounds which are SOLUBLE IN WATER, and which are supposed to consist only of One Acid and One Base, or One Metal and One Non-Metallic Body.

The original solution is either acid, alkaline, or neutral. If acid, add as much NH_3 as will impart a slight alkaline re-action to it, no matter whether this addition of NH_3 at first produces a precipitate or not, and further, add some sal-ammoniac. (Observ. *a*.) If alkaline, add solution of sal-ammoniac, and neutralize with NO_5 (dilute), but so as to leave a slight alkaline re-action. If neutral, add solution of sal-ammoniac (Observation *b*) and a drop or two of NH_3. If the examination for bases has shown the presence of heavy metallic oxydes, it is best to remove them before testing for the organic acids. Wherefore, if the solution is neutral or alkaline, add as much dilute HCl as will impart a decided acid re-action, pass then a stream of HS through the liquor to supersaturation, filter, add NH_3 + NH_4S, filter, add dilute NO_5 in excess to the filtrate, and boil the filtrate until it no longer smells of HS; when cold, add as much NH_3 as will impart to the filtrate a slight alkaline re-action, no matter whether or not this produces a precipitate, add an excess of sal-ammoniac, and filter, if necessary. *To the cold liquor* so prepared, add solution of CaCl, and shake the mixture well at intervals of a few minutes. If no precipitate is then produced in the cold, boil the liquor. If no precipitate is then produced, add alcohol If no bases but alkalies, or alkaline earths are present, the solution, being rendered slightly alkaline (either by an addition of NH_3 or of NO_5, as the case may be), is treated, as first mentioned, with sal-ammoniac and CaCl.

White, or Whitish precipitate, produced in the cold.

Presence of $\overline{T}$,2HO. — $\overline{R}$,2HO — $\overline{O}$,HO — $\overline{Qt}$,3HO — $\overline{Me}$,3HO
($C_8H_4O_{10}$,2HO) ($C_8H_4O_{10}$,2HO) (C_2O_3,HO) ($C_{18}H_5O_9$,3HO) ($C_{14}HO_{11}$,3HO).

To another portion of the neutral original solution add an excess of lime-water, shake violently, and to the liquor containing the precipitate, add an excess of solution of sal-ammoniac, and, if necessary, that is, if the re-solution of the precipitate is not effected in the cold, apply heat. (Observation *c*.)

Precipitate re-dissolves	Precipitate remains Insoluble.	
$\overline{T}$,2HO	$\overline{R}$,2HO - $\overline{O}$,HO	$\overline{Qt}$,3HO—$\overline{Me}$,3HO
	To another portion of the original *and neutral* solution add solution of CaO,SO_3.	To another portion of the original and neutral solution, add Fe_2Cl_3.
	O.	**White precipitate.**
	$\overline{T}$,2HO Confirm. Add to another portion of the original and neutral solution some CaCl, and then immediately, some KO in excess.	$\overline{R}$,2HO. $\overline{O}$,HO Evaporate a portion of the original solution to dryness, and throw a portion of the dry residue (or of the original substance if in the solid state) upon a clean thin iron or platinum plate, heated by a spirit-lamp, or upon ignited charcoal. (Observation *d*.)
	White precipitate, which immediately dissolves.	Odour of burnt Sugar. / Acid fumes.
	Apply heat.	$\overline{R}$,2HO. / $\overline{O}$,HO.
	White Precipitate re-appears.	
	$\overline{T}$,2HO See Dictionary.	
	$\overline{T}$,2HO.	$\overline{R}$,2HO. / $\overline{O}$,HO.
	1	2 / 3

Black Colour,	In the cold,	NO PRECIPITATE, either in the cold, nor by boiling, nor by addition of alcohol.	
and the superincumbent liquor is	O	To another portion of the original solution *exactly* neutralized, if necessary, with NH_3, or with dilute HCl, as the case may be, add a solution of Fe_2Cl_3. (Observations *j*, *k*, *l*, *m*.)	
Green.	$\overline{Ci}$,3HO — $\overline{M}$,2HO. **Boil the liquor.**	**Bulky Light Brown precipitate.**	**Dark Red Colour, but no ppte.**
$\overline{G}$,3HO (C_7HO_3,3HO) Test a fresh portion of the original and neutral solution with gelatine.	**White.** (Observation *h*.) $\overline{Ci}$,3HO ($C_{12}H_5O_{11}$,3HO.) / Nothing but by adding alcohol, **White.** $\overline{M}$,2HO ($C_2H_4O_8$,2HO.)	$\overline{S}$,HO — $\overline{Bz}$,HO ($C_4H_2O_3$,HO) ($C_{14}H_5O_3$,HO.) Decant, and mix the light brown precipitate obtained with excess of NH_3, boil, and filter. Concentrate the filtrate by evaporation, add alcohol, and divide into two portions.	$\overline{A}$,HO — $\overline{Fo}O_3$,HO ($C_4H_3O_3$HO) (C_2HO_3,HO.) Boil, and leave at rest for about a quarter of an hour.
O	To a portion of the original and neutral solution add solution of PbO,$\overline{A}$ and boil	1ST PORTION. Into this first portion of the alcoholic filtrate pour solution of BaCl.	**Reddish-Brown precipitate.**
Test another portion of the original solution with Fe_2Cl_3.	**White Curdy. precipitate.** / **White viscid or clammy precipitate.**	**White precipitate.** / **O**	$\overline{A}$HO.—$\overline{Fo}$,HO. Take a portion of the original substance, if in the solid state, or else neutralize a portion of the original solution with KO, evaporate to dryness, put a portion of the dry residue into a glass test-tube, add concentrated SO_3, and apply heat.
Black Colour.	$\overline{Ci}$,3HO. (See Table XXII.—A., Observation *j*.) / (Observation *i*.) $\overline{M}$,2HO.	$\overline{S}$,HO / $\overline{Bz}$,HO	Odour of $\overline{A}$,HO. / Effervescence, inflammable gas, CO.
$\overline{G}$,3HO. (Observation *g*.)		2ND PORTION. To this second portion of the alcoholic filtrate add a slight excess of HCl.	
		O / **Milkiness or White precipitate.**	$\overline{A}$HO. / $\overline{Fo}O_3$,HO.
		$\overline{S}$,HO. (Observ. *j*, *k*, *l*.) / $\overline{Bz}$,HO. (Observ. *j*, *k*, *l*.)	(Observation *n*.) / (Observations *n*, *o*.)
$\overline{G}$,3HO.	$\overline{Ci}$,3HO. / $\overline{M}$,2HO.	$\overline{S}$,HO. / $\overline{Bz}$,HO.	$\overline{A}$,HO. / $\overline{Fo}O_3$,HO.
6	7 / 8	9 / 10	11 / 12

OBSERVATIONS ON TABLE VIII.

GENERAL REMARKS.

a. If the concentrated aqueous solution is very acid, the addition of sal-ammoniac is unnecessary, since the NH_3 added to neutralize the acid will form the required quantity of ammoniacal salt. *

If the aqueous solution of the compound is very acid, the first addition of ammonia often produces a white precipitate long before neutralization is attained, this is particularly the case with $\overline{T}$,2HO this precipitate, however, disappears upon adding NH_3 to neutralization. If sal-ammoniac exists in the liquor in sufficient quantity, the addition of ammonia causes no precipitate.

b. If the original solution is only slightly alkaline, there is, of course, no occasion for the addition of NO_5, which is only used for the purpose of neutralizing when an alkali is present in excess, but sal-ammoniac must be added.

If the solution contained lead or mercury, &c., the addition of an excess of sal-ammoniac would, of course, produce a precipitate, wherefore the precipitate thus formed should either be removed by filtering, or, better still, the metallic oxyde should be removed by HS, as mentioned in the general directions, before testing at all for organic acids.

If oxyde of chromium is present, it should be precipitated by excess of ammonia, removed by filtering, and the ammoniacal liquor should be neutralized by HCl, but so as to leave a slight alkaline reaction. It would now be superfluous to add sal-ammoniac to the liquor, since the HCl employed to neutralize the NH_3 will have probably produced a sufficient quantity of that salt.

The application of HS and then of NH_4S is of course subordinated to the presence of the metallic oxydes, which require this mode of treatment for their removal before submitting the liquor to the Systematic Analysis for Organic Acids.

Group 1 *to* 5.

c. Tartrate of lime is soluble both in solutions of sal-ammoniac and of tartaric acid, but after a certain time—which depends on the state of concentration of the liquor—tartrate of lime is deposited from its solution in sal-ammoniac.

d. (Col. 2, 3.) Tartaric acid and the tartrates, and also racemic acid and the racemates, when thrown upon a heated plate, evolve an odour of burnt bread or burnt sugar, and charring always takes place, which is not the case with oxalic acid and the oxalates.

e. (Col. 4.) If tannic acid ($\overline{Qt}$, 3HO) is present, the addition of NH_3, in the first instance, will have imparted a brownish colour to the liquor, and that of NH_4Cl will have caused a turbidness or precipitate.

f. (Col. 5.) This want of decolourizing power of a solution of corrosive sublimate is important, and perfectly distinguishes *meconic acid* from *sulpho-cyanic acid*, which yields also a blood-red colour with a per-salt of iron, but which is immediately decolourized by solution of corrosive sublimate.

Group 6.

g. If gallic acid, or a soluble gallate is present, the first addition of NH_3 to the original liquor will have imparted to it a reddish-brown colour, becoming green, and sometimes purple, but sal-ammoniac will have produced no precipitate. The addition of BaCl forms a black precipitate sometimes immediately, *but always after a few minutes*, and the supernatant liquor is dingy green.

Group 7.

h. It is perhaps necessary to observe here, that solution of acetate of alumina, when perfectly neutral (unless the salt be perfectly pure), becomes turbid by boiling, but it reassumes its original limpidity on cooling.

Group 8.

i. It is only by boiling that the precipitate produced by PbO, $\overline{A}$, in malic acid ($\overline{M}$,2HO) becomes agglomerated into a clammy, transparent mass, insoluble in water, but soluble, at least to a large extent, *with the help of heat*, in all dilute acids, from which it separates, on cooling, in crystals of a silvery appearance.

Group 9, 10.

j. If NaO,NO_5 is present, no precipitate will be produced by Fe_2Cl_3, though succinic acid may exist in the liquor.

k. In testing for succinic acid with Fe_2Cl_3, the original solution must be *exactly* neutral, because per-succinate of iron is soluble both in free acids, even in free succinic acid, and in free ammonia.

This remark applies also to benzoates, which are decomposed either by excess of NH_3, or of the strong acids.

l. The precipitate produced by Fe_2Cl_3 in solutions of benzoates, and of benzoic acid, is more bulky, and of a lighter colour than that produced by the same reagent in solutions of succinic acid, and of succinates.

Group 11, 12.

m. In testing for $\overline{A}$,HO with Fe_2Cl_3, it is necessary to use a very concentrated and exactly neutralized solution, and a large excess of Fe_2Cl_3 should be employed.

n. (Col. 11.) The best test of the presence of acetic, or of formic acid, consists in distilling the substance under examination with dilute sulphuric acid, and digesting the distillate with an excess of oxyde of lead *in the cold*. If any acetic acid is present the lead dissolves, and the liquor *has an alkaline reaction*. It is true that formic acid dissolves oxyde of lead also, but the solution, if it has taken place in the cold, *has not an alkaline reaction*. It is important to eschew heat, because formic acid, when heated in contact with oxyde of lead, yields a solution which has also an alkaline reaction.

o. Heated with a solution of corrosive sublimate (HgCl), the latter salt is brought to the state of calomel (Hg_2Cl), if formic acid is present. The gas evolved by heating $\overline{Fo}$,HO with concentrated SO_3 is *CO*, and consequently it burns with a blue flame when ignited.

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* *a.* Yet it is necessary to make sure that the solution is very acid, or the operator must render it so if he wishes to dispense with the addition of sal-ammoniac.

TABLE IX.

Systematic Analysis of Compounds INSOLUBLE IN WATER but SOLUBLE IN ACIDS, and which are supposed to consist of only ONE BASE and ONE ACID, or ONE METAL and ONE NON-METALLIC BODY.

Take a portion of the solution of the compound in HCl, in NO_5, or in Aqua Regia, as the case may be. (See TABLE I.—E., II.—B., and III.; Observations *a* to *l*.) Evaporate to syrupy consistence (observe whether any odour is evolved or deposit formed, Observ. *f* to *h*,) and pour a few drops of it in a long test-tube full of water.

Milkiness, Turbidness, or White precipitate.

Presence of Sb—Sn—Bi—(Observation *i*.)
To the milky or turbid liquor add excess of T,2HO.

Milkiness DISAPPEARS.	Milkiness REMAINS.	
Presence of Sb.	Presence of Bi.—Sn.	
Confirm by passing a stream of HS through this solution.	Passing a stream of HS through the original solution produces a	Passing a stream of HS through a portion of the original solution produces a
Orange Red.	**Black ppte.**	**Yellow.** / **Chocolate Brown ppte.**
Sb. See besides TAB. IV. Col. 13.	Presence of Bi. Test a fresh portion of the original solution with KO,CrO_3	SnO_2 / SnO
	Yellow.	Confirm as directed. TAB. IV. Col. 14—16.
	Bi. See TAB IV. Col. 8.	
Sb	Bi.	SnO SnO_2.
1	2	3

TREATMENT OF THE SOLUTION in the proper Acid.

(See TABLE I.—E., II.—B.) by HS.
See also TABLE XXIII., Observations *a*, *b*, *c*.

Take a portion of the original acid solution diluted with water, and pass a stream of HS through it, until fully saturated (Observations *j*, *k*), or pour aqueous solution of HS.
The operator should read also the Observations on TABLES XXIII. and XXIV.

O.	Green.	Black.	Orange Red.	Brown.	White.	Yellow.
Go from Col. 11 to the end. (Ob. *l*.)	Cr_2O_3. See TAB. IV. Col. 6.	PbO BiO CuO AgO Hg_2O HgO AuO_3 PtO_2 possibly, Te Pd Rh. See TAB. IV. Group 1 to 12.	Sb. See TAB. IV. Col. 13.	SnO. See TAB. IV. Col. 14.	(Ob. *k*.) Fe_2O_3 S. See TAB. IV. Col. 15.	SnO_2 AsO_3 AsO_5 CdO possibly Se. See TAB. IV. Group 16 to 19.
4	5	6	7	8	9	10

TREATMENT OF THE ACID SOLUTION BY NH_4S.

If HS has produced no precipitate, as just said, in the acid solution of the compound, take a fresh portion of the original and acid solution (concentrated by evaporation, if necessary), add NH_3 thereto, until an alkaline reaction is manifested, and also some NH_4Cl, should there not be enough acid present to form a sufficient quantity of an ammoniacal salt, and whether or not a precipitate is produced by this treatment, add an excess of NH_4S to the whole. If it produces NOTHING, go to TABLE X. If, on the contrary, it produces a precipitate, which is

Black.	Flesh Red.	Greenish	WHITE.
Presence of FeO.—NiO.—CoO. possibly U.	MnO.	Cr_2O_3.	Al_2O_3.—ZnO.—Phosphates, Borates, Oxalates, Arseniates, Fluorides of the alkaline earths.

To another small portion of the original solution in HCl, add a pretty large excess of solution of caustic KO, in the cold. (Table V, Ob. *f p*.)

A precipitate is produced INSOLUBLE in an excess of KO.

Dingy White.	Apple Green.	Fine light Blue.
Dingy Green.	NiO. See TABLE V. Col. 3.	CoO. See TALBE V. Col. 4.
Brown.		
FeO. See TABLE V. Col. 2.		
Black.		
MnO. Confirm by treating a portion of this precipitate before the blowpipe, as described, TAB. I.—B. Col. 23, or to a fresh portion of the solution, add PbO_2, then some dilute NO_5, and boil.		
Purple Red,		
immediately decolourized by SO_2. MnO. See TABLE V. Col. 5. (Obs. *f*, *p*.)		
FeO.	NiO.	CoO.
11	12	13

White.

By exposure the white precipitate becomes

Presence of Phosphates, Borates, Oxalates, Arseniates, Fluorides of earths.
Wash the white precipitate thoroughly, heat it to redness for a few minutes in a platinum capsule, drench the ignited mass with water, and add HCl. It dissolves, if with effervescence, an oxalate is present, ignition having converted it into a carbonate.

Yellowish,

Take a fresh portion of the original solution of the compound in HCl, add thereto a great excess of KO, CO_2, and boil for some time.

Brown,

White precipitate.

Filter, and treat the filtrate and the precipitate as follows:—

Black.

The FILTRATE.	The PRECIPITATE.
To a portion of the filtrate add $\bar{A}$,HO to acid reaction, and test it with CaO,SO_3.	It consists of the bases which were combined with the acid. Dissolve therefore this precipitate in HCl, and examine the nature of the bases thus dissolved, according to the directions given in TABLE X. A portion of the original solution may, of course, be used for that purpose. If no $\bar{O}$,HO has been found, go to Col. 17—20.
White,	
soluble in HCl. $\bar{O}$,HO. Confirm by evaporating a portion of the original solution to dryness, or take a portion of the substance itself, well pulverized, and heat it in a glass test-tube with concentrated SO_3, a gas is evolved, which being inflamed burns with a	
Blue flame.	
$\bar{O}$,HO. (See Obs. *m*.)	
$\bar{O}$,HO.	

Take a fresh portion of the original solution in HCl, saturate it with NH_3 to feeble alkaline reaction, add then as much $\bar{A}$,HO as is necessary to redissolve the white precipitate produced by NH_3. Pour now into the liquor a drop of neutral Fe_2Cl_3

White, with tinge of Yellow.

PhO_5. Add to the same liquor an excess of KO,$\bar{A}$ and then more Fe_2Cl_3, so that the liquor is of a dark brownish red colour (Obs *n*), boil for a few minutes and filter. The filtrate which contains the earths with which the PhO_5 was combined may be examined as directed in TAB. X.

PhO_5.

Take a fresh portion of the original solution, evaporate it to pasty consistence, pour some concentrated SO_3 upon it and then alcohol, stir the mass and inflame the mixture,

Yellowish Green flame.

BO_3.

Bo_3.

Take a fresh portion of the original solution in HCl diluted with water, add solution of SO_2, boil, and pass a stream of HS.

Yellow.

Presence of As. Identify the presence of AsO_5 by adding a few drops of dilute NO_5 thereto, and then AgO,NO_5, until a precipitate is no longer produced; filter, add a few drops of AgO,NO_5 more, which should not produce a precipitate, and then NH_3 to neutralization.

Light Brown.

AsO_5. (See Obs. *o*.)

AsO_5.

Evaporate a fresh portion of the original solution to dryness, or else take a portion of the substance itself, well pulverized and transfer it to a platinum crucible. Pour concentrated SO_3 upon the mass, cover the crucible with a plate of glass coated with wax, through which lines have been traced with a pointed brass wire, as directed in the observations on Col. 14, TABLE VII.

Corrosion.

Presence of Fl.

Fl.

The Precipitate REDISSOLVES in an excess of KO.

To a portion of the clear, and therefore, strongly alkaline potash-solution of the precipitate just alluded to, add HS. If NO PRECIPITATE is produced, and Al_2O_3 is not found, as in Col. 24, go to TABLE X.

Greenish	White.	O.
Presence of Cr_2O_3. See TABLE V., Col. 10.	Presence of ZnO. Confirm. Take a portion of the precipitate produced by HS in the KO solution, or a portion of the substance itself, put it on a strip of platinum, and having moistened it with a drop of CoO,NO_5, heat it before the blow-pipe.	Al_2O_3, or phosphate of alumina. To another portion of the original solution in HCl add an excess of T,2HO (Observ. *p*), and likewise an excess of NH_3, and test the clean filtrate with MgO,SO_3.
	Emerald Green.	**White precipitate.**
		Presence of PhO_5. (See Observ. *i*—*l*, TABLE XVIII.)
		White precipitate.
		Al_2O_3. Filter, wash the precipitate, and boil it with KO.
		Dissolves.
		and is reprecipitated by boiling with NH_4Cl.
		Al_2O_3.
Cr_2O_3.	ZnO.	Al_2O_3.
21	22	23	24

OBSERVATIONS ON TABLE IX.

Group 1 *to* 3.

a. Remember that AgO and Hg_2O are not soluble in HCl, or are completely precipitated from their solutions by that acid; if, therefore, the compound dissolves entirely in HCl, it is evident that neither AgO nor Hg_2O can be present; the latter, however, is converted into corrosive sublimate (HgCl), by *aqua regia*, and even by boiling with HCl; and corrosive sublimate is soluble in water. If the compound has dissolved in HCl, it is probable also that the more rare substances, tantalic, titanic, and tungstic acids are absent, as will be seen in the Supplementary Tables.

b. AgO is, of course, soluble in NO_5, and if strong NO_5 is employed, sub-oxyde of mercury (Hg_2O) is thereby converted into a per-nitrate of mercury (HgO,NO_5).

c. PbO is only sparingly soluble in HCl, and is far from being precipitated completely by that acid. (See Observ. *e*, Table IV.) It is, however, very soluble in NO_5.

d. HCl, poured in a solution of either AgO—PbO, or Hg_2O, produces a white precipitate, which, treated by excess of NH_3, remains white, if it is due to the presence of lead; turns black if it is due to that of mercury; and immediately disappears if it is due to that of silver. (Table IV., Col. 1 to 3).

e. Per-chloride of mercury (Hg Cl), however, is not precipitated by HCl, and NH_3 produces *not a black*, but a *white* precipitate. Therefore, if a solution, treated by HCl, does not afford a white precipitate, or if one being produced, it is not rendered black by an excess of NH_3, the operator, after paying due regard to Observations *a* and *e*, may conclude that no sub-salt of mercury (Hg_2O) is present; and if the subsequent examination, as directed Table IV., Col.10.indicates the presence of mercury, then it must be a per-salt of mercury (HgO), for otherwise it would have been precipitated in the first instance by HCl.

f. If, while boiling with HCl, an odour of Cl is evolved it may be due to the presence of one of the substances already mentioned in Table I.—E., Col. 6, some of which are not taken account of in this Table, but will be examined in the Supplementary Tables.

g. The odour evolved by treatment with HCl must already have been noticed when submitting the substance to the preliminary examination in Table I.—E, Col. 3 to 9; and a clue as to the nature of the deposit or precipitate, or portion insoluble in that acid, will also have been obtained from the process mentioned in that Table (I.—E.), in Col. 13 to 22, and in Table I.—B., Col. 12, and Table I.—A., Col. 16.

h. If a residue or precipitate, or insoluble portion is produced by treatment with the acid, it may be also sulphur or an insoluble sulphate, as explained in Table I.—E., Observ. *l*, *n*, and *p*, to the end.

i. Although a milkiness or turbidness may not be produced by dilution with water, the operator must not conclude that neither Sb,—Bi, nor Sn, are present, for it frequently happens that their dilution with water fails to produce the characteristic milkiness, either because the solution contains too much acid, or because some organic matter is present.

The presence of Sb—Bi—Sn will doubtless have been detected in the preliminary examination, namely, Sb in Table I.—B., Col. 2, 14, and Table I.—E., Col. 11, 19, 20; Bi in Table I.—A., Col. 25, Table I.—B., Col. 16, and Table I.—E., Col. 11, 14; and Sn in Table I.—B., Col. 12, 21, and Table I.—E., Col. 11, 20.

Group 4 *to* 10.

j. I have already said how to ascertain whether the liquor is perfectly saturated with HS. (See Table IV., Observ. *k*.)

It is important not to employ much more acid than is necessary to dissolve the compound, or if too much has been employed the great excess should be expelled by evaporation, since, as we said before, most bases cannot be precipitated by HS in very acid solutions. If, however, such a solution be largely diluted with water, HS may then cause a precipitate; but the bulk of the liquid is so inconveniently increased that it is much better, in every way, not to use much more acid than is necessary, or to evaporate the excess.

k. In passing a stream of HS through the acid solution, especially that in *aqua regia*, a milkiness is frequently produced, which might be erroneously ascribed to the presence of per-oxyde of iron (Fe_2O_3), but which is altogether due to a separation of sulphur resulting from the decomposition of the HS by the acid of the solution; free chlorine or *aqua regia*, nitric, sulphurous, iodic, chromic acids, &c., produce also this effect.

l. Remember that if arsenic acid or an arseniate be present, HS takes a long time to produce a yellow precipitate, yet heat considerably hastens its formation.

Group 14 *to* 20.

m. (Col. 15.) The mode of testing for oxalic acid, by heating the compound with concentrated SO_3, has been described in the notes on Col. 15, Table VII.

n. (Col. 17.) In testing for phosphoric acid, the operator is directed to add an excess of $KO,\overline{A}$, and then Fe_2Cl_3, until a dark red liquid is obtained. But if too little $KO,\overline{A}$ has been added, the precipitate at first formed by Fe_2Cl_3 will disappear, and the liquor will hardly be more coloured than that of the Fe_2Cl_3 employed as reagent, it is a sign that more $KO,\overline{A}$ must be poured into the solution, which will then become dark reddish-brown, and will yield a dark reddish-brown precipitate, *after boiling for a few minutes, provided enough* $KO,\overline{A}$ *has been added*, for otherwise the liquor remains reddish-brown, but does not precipitate by boiling; but if enough $KO,\overline{A}$ has been added, the above precipitate takes place, and the superincumbent liquor filtered is perfectly clear, and contains the earths which were combined with the phosphoric acid. (See Table XVIII., Obs. *i*, Table XXI., Obs. *h*, and Table XXII.—A., Obs. *n*.)

o. (Col. 19.) In order to ascertain whether the original solution contains arsenic in the state of arsenic acid (AsO_5), the solution must have been made in HCl, since arsenious acid (AsO_3) is converted into arsenic acid (AsO_5) by NO_5, and by *aqua regia*. The addition of AgO,NO_5 to the acid original solution in HCl will, of course, produce a precipitate of chloride of silver, wherefore this reagent should be added in greater quantity than is sufficient to precipitate the whole of the chlorine, and when AgO,NO_5 ceases to produce a precipitate, a little more of it should be added, and also a few drops of dilute nitric acid; NH_3, being now added to the acid filtrate nearly to neutralization, will produce a light brown precipitate of arseniate of silver ($AsO_5,3AgO$), which becomes permanent as soon as enough NH_3 has been added nearly to neutralize the liquid.

Group 21 *to* 24.

p. This addition of $\overline{T},2HO$ to the hydro-chloric acid solution of the precipitate produced by HS in the potash solution of the substance is for the purpose of keeping Al_2O_3 in solution, for in presence of a solution containing an organic body like $\overline{T},2HO$ which cannot be volatilized by heat without undergoing decomposition, the usual reagents employed, even in a large excess, for precipitating Al_2O_3, fail in doing so. ZnO is very soluble in excess of ammonia. Both these reagents, namely, $\overline{T},2HO$ and NH_3, should be added in such quantity as to obtain a clear liquid.

TABLE X.

Systematic Analysis of Compounds INSOLUBLE IN WATER but SOLUBLE IN ACIDS, and which are supposed to consist of only ONE BASE and ONE ACID, or ONE METAL and ONE NON-METALLIC BODY.

TREATMENT OF ACID SOLUTIONS NOT PRECIPITATED BY HS, NOR BY NH_4S, or of the liquors filtered from the precipitate produced by NH_4S, as mentioned in TABLE IX.

Take a portion of the original solution, slightly supersaturated with NH_3 (Observation *a*), and whether or not a precipitate is produced, add an excess of solution of NH_4O,CO_2, and boil.

White Precipitate,
Insoluble in sal-ammoniac, and which does not disappear by protracted boiling (Observation *b*, on TABLE VI.)

Presence of BaO.—StO.—CaO.
Concentrate a portion of the original acid solution by evaporation, and add thereto a solution of CaO, SO_3. (Observation *b*.)

White Precipitate,
either immediately, or after some time.

Presence of BaO.—StO.
To another portion of the original acid solution concentrated by evaporation, add $\overline{(2SiFl_3)\ 3HFl.}$ (See observations on Group 1 to 3, TABLE VI.)

White.

BaO.
Confirm by testing another portion of the original solution by $KO,2CrO_3$.

Yellow Precipitate.

Observation *c*.
See also Col. 1, TABLE VI., and Observations thereon.

Ba.

1

O.

St.
Confirm by treating with alcohol and inflaming.

Carmine Red Flame.

See Col. 2, TABLE VI., and Observations thereon.

St.

2

O.

Presence of CaO.
Confirm by testing another portion of the solution with $NH_4O,\overline{O}$.

White Precipitate.

See observation *d*.
See also Col. 3, TABLE VI., and Observations thereon.

CaO.

3

White precipitate or turbidness, immediately soluble in NH_4Cl, or by protracted boiling.

Presence of MgO.
Confirm by adding to the original solution of the compound previously neutralized by NH_3 a solution of $\overline{(2NaO)HO,PhO_5}$.

White Precipitate.

Also by KO,CO_2, or NaO,CO_2, and boiling.

White Precipitate.

Also by moistening a portion of the precipitate with CoO,NO_5, and heating before the blow-pipe.

Pink Coloured Mass.

See TABLE VI., Col. 4, and Observations thereon.

Mg.

4

NO PRECIPITATE OR TURBIDNESS,
by HS, nor by NH_4S, nor by NH_4O,CO_2, nor by $\overline{(2NaO)HO,PhO_5}$, even after boiling.

Presence of KO.—NaO.

The only compounds of K, or of Na insoluble in water are some of the combinations of SiO_3 with these bases. All the other salts of potassium and of sodium being soluble in water, the base will have been detected in TABLE IV., V., VI., and the acid in TABLE VII., VIII.

In order to detect the presence of silicic acid (SiO_3), evaporate the acid solution to perfect dryness, add water to the perfectly dry mass, boil, and filter. The white, gritty mass left in an insoluble state is SiO_3. (Observation *e*.) The filtrate contains now the base with which the SiO_3 was combined. Concentrate, therefore, the filtrate thus obtained, neutralize a portion of it with NaO,CO_2, add an excess of $\overline{T},2HO$, and shake the whole violently.

White Granular Precipitate.

Presence of KO.
Confirm by adding to another portion of the original solution acidified by HCl, and to which no NH_3 has been added, a solution of $PtCl_2$, and alcohol.

Yellow Precipitate.

See TABLE VI., Col. 6, and Observations thereon.

KO.

5

O.

Presence of NaO.
Confirm by evaporating a portion of the original solution, to which no NH_3 has been added, to pasty consistence; add alcohol and inflame; burns with a

Yellow flame.

See TABLE VI., Col. 7, and Observations thereon.

NaO.

6

OBSERVATIONS ON TABLE X.

GENERAL REMARKS.

a. It has already been remarked in the Observations on TABLE VI., that if, on slightly supersaturating the original solution with NH_3, a white precipitate or turbidness was produced, MgO is certainly present. It is important to bear in mind the Observations made on TABLE VI., because they apply entirely to the present Table, (See, therefore, Observations on TABLE VI., and especially Observation *i*), since the present original solution being acid, may contain a phosphate, an arseniate, an oxalate, or a borate of the earths.

Group 1 *to* 3.

b. Pay particular attention to the Observation *i*, on TABLE VI., which apply here also.

c. If the solution be very acid, the excess of acid should be evaporated, or neutralized before testing for baryta by $KO,2CrO_3$, because otherwise no yellow precipitate would be produced, since chromate of baryta is soluble in an excess of acid, especially of nitric acid.

The bi-chromate ($KO,2CrO_3$) should be preferred to the neutral chromate (KO,CrO_3), because its reaction is much more characteristic; in effect the bi-chromate produces immediately a precipitate in solutions of baryta salts, but produces none in those of strontia. The neutral chromate produces also an immediate precipitate in solutions of baryta salts, but in solutions of salts of strontia, a precipitate is produced by that reagent, if not immediately, at any rate after a length of time proportionate to the state of concentration of the liquor; and, by boiling, a copious yellow precipitate of neutral chromate of strontia is at once determined. If a drop of NH_3 be poured into a solution of a strontia salt, after addition of bi-chromate of potash, the clear liquor at once deposits a yellow precipitate by boiling. See also TABLE VI., Observation *c*.

d. If the solution be acid, it should be neutralized by NH_3, since oxalate of lime is soluble in acids. Of course the operator will have made sure that strontia is not the base in the liquor, for strontia is precipitated by $NH_4O,\overline{O}$ in even dilute neutral or alkaline solutions.

Group 5 to 6.

e. The silicic acid left after evaporating the original acid solution, instead of being white, is generally brownish, owing to the presence of per-oxyde of iron. In order to obtain it white, the dry mass should be drenched with concentrated HCl, and left to digest for about ten minutes; then, on adding water and boiling, the silicic acid will be left in an insoluble state, in the shape of a perfectly white and gritty powder. The per-oxyde of iron may then be precipitated by supersaturating with NH_3, filtering and testing the filtrate for potash or soda, as directed.

TABLE XI.

Systematic Analysis of Compounds INSOLUBLE in WATER but SOLUBLE in ACIDS, and which are supposed to consist of only ONE BASE and ONE ACID, or only ONE METAL and ONE NON-METALLIC BODY.

Take a portion of the compound, well pulverized, drench it with moderately dilute HCl, boil, and filter if necessary. (See Observations *a*, *b*.)

EFFERVESCENCE.

Presence of CO_2—HS—SO_2.

NO ODOUR

Presence of CO_2.

Confirm by treating a fresh portion of the compound with HCl, and testing the gas evolved with lime-water, as described, TABLE VII., Col. 1.

White.

CO_2.

CO_2.

ODOUR of HS.

Sulphuret.

Confirm by treating a fresh portion of the compound with HCl, and testing the gas evolved with PbO,$\overline{A}$, as described, TABLE VII., Col. 2.

Black.

HS, or Sulphuret.

HS.

ODOUR of SO_2.

Sulphite.

Confirm by treating a fresh portion of the compound with SO_3, diluted with its own bulk of water, and apply heat if necessary.

Odour of SO_2.

Throw a portion of the pulverized compound into nitre in a state of fusion, dissolve the fused mass in water, filter, and test the filtrate with BaO,NO_5.

White Precipitate.

SO_2. (Observat. *b*.)

SO_2.

NO EFFERVESCENCE.

CrO_3—AsO_3—AsO_5.

Pass a stream of HS through the warm solution in HCl (to which SO_2 should be first added) until it is quite saturated with the gas.

If the liquor becomes

Yellow.

Possible presence of AsO_3—AsO_5 (mixed or not with a metallic sulphuret). (Observ. *c*.) Dry the precipitate at a gentle heat, and, when perfectly dry, mix it intimately with one part of NaO,CO_2 + two parts of KCy, roll it into a little ball with saliva and introduce it into a small glass tube of German glass, as described in the Observations on Col. 17, TABLE IV., to obtain a mirror of As.

Take another portion of the precipitate produced by HS in the original solution of the compound, but to which no SO_2 has been added, (Obs. *d*.) wash it thoroughly with water, and digest it in solution of KO; boil the solution filtered therefrom with solution of $Bi_2O_3,3NO_5$, filter, add NO_5 and an excess of AgO,NO_5, filter, and to the filtrate add, gradually and carefully, as much NH_3 as is sufficient to leave the liquor very slightly acid.

Yellow. | **Brick Red.**

AsO_3. | AsO_5.

Black, or Blackish.

Possible presence of AsO_3—AsO_5 (mixed or not with a metallic sulphuret). (Observ. *c*.) Dry the precipitate at a gentle heat, and, when perfectly dry, mix it intimately with one part of NaO,CO_2 + two parts of KCy, roll it into a little ball with saliva and introduce it into a small glass tube of German glass, as described in the Observations on Col. 17, TABLE IV., to obtain a mirror of As.

Take another portion of the precipitate produced by HS in the original solution of the compound, but to which no SO_2 has been added, (Obs. *d*.) wash it thoroughly with water, and digest it in solution of KO; boil the solution filtered therefrom with solution of $Bi_2O_3,3NO_5$, filter, add NO_5 and an excess of AgO,NO_5, filter, and to the filtrate add, gradually and carefully, as much NH_3 as is sufficient to leave the liquor very slightly acid.

Yellow. | **Brick Red.**

AsO_3. | AsO_5.

Greenish,

or if a precipitate being formed, the supernatant liquor is

Greenish.

CrO_3.

Confirm with Borax before the blow-pipe,

Emerald Green,

according to the directions in TABLE VII., Col. 9.

CrO_3.

TREATMENT WITH NITRIC ACID.

Take a portion of the substance under examination, pulverize it well, and boil it with pure NO_5.

Effervescence, the gas evolved and the liquor are

Colourless and odourless.

CO_2.

Confirm as described in Col. 1.

CO_2.

Ruddy Fumes, especially by boiling, with or without effervescence. (Observation *e*.)

Sulphuret—Bromide or Bromate.

Odour of nitrous acid.

Sulphuret.

Confirm by filtering and treating the filtrate with BaO,NO_5.

White.

Insoluble in water and in acids.

Sulphuret.

Obs. *f*.

HS.

The liquor has a red-brown or yellowish brown colour (Observ. *g*), and there is an

Odour resembling Cl.

Bromide or Bromate.

Confirm by mixing a little ether with the liquor, and shake. On settling, the ether will float at the top, forming a layer of a red-dish-brown colour, which is a solution of Bromine in Ether. Bromides are distinguished from Bromates in Cols. 14, 15.

HBr. BrO_5.

Purple Fumes,

and Odour of I.

Iodide.

Confirm by suspending over the liquor a strip of paper moistened with mucilage of starch.

Blue.

Iodide.

HI.

Filter the solution of the substance in NO_5, and test a portion of it with AgO,NO_5.

White Precipitate,
possibly with a tinge of **Yellow.**

Presence of Cl or HCl—Cy or HCy—Br—BrO_5 or HBr.—I or HI.—$\overline{O}$,HO. (Observation *h*.)

To the liquor containing the precipitate produced by AgO,NO_5, add NH_3 *in excess*, and, if necessary, apply heat.

The Precipitate Dissolves *at once* in the cold.

Presence of Cl—$\overline{O}$,HO.

Test a portion of the compound, or of the precipitate, with microcosmic salt before the blow-pipe on a brass wire, as described, TABLE VII., Col. 21.

Blue Flame.

Cl.

HCl.

Test a fresh portion of the solution with CaO,SO_3, as described, TABLE VII., Col. 15.

White.

Insoluble in $\overline{A}$,HO.

$\overline{O}$,HO.

The Precipitate Dissolves, but not so readily, or heat must be applied to dissolve it.

Cyanide—Bromide—Bromate.

To a portion of the original solution add KO, and then FeO,SO_3.

Blue.

Test another portion with NH_4S and Fe_2Cl_3, as described, TABLE VII., Col. 20.

Blood Red. Colour.

Cy.

HCy.

To the liquor containing the precipitate produced by AgO,NO_5 add aqueous solution of Cl, and then a little ether, as described, TABLE VII., Cols. 22, 23. The layer of ether is

Hyacinth Red.

Br.

Mix another portion of the precipitate produced by AgO,NO_5 with pulverized sugar, and throw upon red hot foil of platinum. (Observation *i*.)

Deflagration.

BrO_5.

No Deflagration.

HBr.

The Precipitate DOES NOT Dissolve.

Iodide, in which case, I will have been detected in Col. 10, by the violet colour of the fumes when boiled with NO_5, and by the blue colour imparted to moistened starch-paper.

HI.

TREATMENT WITH HCl.

Take a portion of the compound under examination, well pulverized, if possible, and boil it with pure HCl, filter if necessary.

Evaporate to perfect dryness a portion of the clear acid solution.

White, Gritty, Residue.

Insoluble in HO and in HCl.

SiO_3.

Confirm by triturating the white, gritty, insoluble residue to impalpable powder, mix with five or six times its weight of NaO,CO_2, place the whole in small platinum blow-pipe capsule, fuse the mass with blow-pipe, after cooling pour HO and a little HCl on the mass in capsule.

White and Gelatinous Residue.

SiO_3. (Observation *j*.)

SiO_3.

Take another portion of the above solution in HCl, dilute with water, and add thereto some BaCl.

White Precipitate.

Insoluble in water, and in acids.

SO_3. (Observat. *k*.)

SO_3.

Take another portion of the solution of the compound in HCl, dilute with water, and pass a stream of HS through it (Observation *l*), filter if necessary. To the filtrate add an excess of NH_3, and then some NH_4S, as long as a precipitate is produced, filter again if necessary, and to the filtrate add a few drops of CaCl. (Observation *m*.)

White Precipitate.

Fl.—$\overline{O}$,HO.—PhO_5.

To the alkaline liquor containing the precipitate add an excess of $\overline{A}$,HO.

Precipitate is insoluble therein.

Fl—$\overline{O}$,HO. Add HCl to the precipitate.

Remains Insoluble.

Fl.

Confirm by treatment with SO_3, as directed, TABLE VII., Col. 14, and Observations thereon.

Corrosion.

HFl.

Dissolves.

$\overline{O}$,HO.

Add excess of NH_3, and boil.

Precipitate reproduced.

Confirm with SO_3, as described, TABLE VII., Col. 15.

Blue Flame.

$\overline{O}$,HO.

Precipitate dissolves.

To a fresh portion of the original solution add dilute NO_5, and *an excess* of AgO,NO_5, filter, and add to the filtrate NH_3, nearly to neutralization.

Yellow.

See Observations on Col. 16, TABLE VII. PhO_5.

PhO_5.

TREATMENT WITH SO_3.

Pulverize the compound and mix it in a platinum crucible with concentrated SO_3. Cover the crucible with a piece of glass coated with wax, through which some writing has been traced, and apply a very gentle heat. (See Observations on Col. 14, TABLE VII.

Corrosion.

Fl.

Take another portion of the solid compound (or, if in solution, evaporate it to dryness, and take a portion of the dry residue), drench it with concentrated SO_3, and apply heat.

Purple Fumes.

Confirm by holding a strip of paper, moistened with starch, over the liquid, as described, Col. 10.

Blue.

I.

IO_5.

Ruddy Fumes, with or without effervescence.

Sulphurets, Bromates, Bromides. Proceed as described in Col. 9.

To another portion of the pulverized compound, drenched with SO_3, add alcohol. Stir the mass and ignite the alcohol, as described, TABLE VII., Col. 17.

Green Flame.

BO_3.

BO_3.

Take another portion of the compound and heat it in a tube with a mixture of equal bulks of concentrated SO_3 and water, after first adding some clean copper-filings.

Ruddy Suffocating Fumes.

NO_5. (Observation *n*.) The presence of free NO_5 may be detected as described in the Observations on Col. 27, TABLE VII.

NO_5.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

OBSERVATIONS ON TABLE XI.

Group 1 *to* 3.

a. If the solution containing a sulphite is not very concentrated, the addition thereto of HCl, or better still, of SO_3, will disengage the sulphurous acid, but *without effervescence.*

b. Hyposulphites being soluble in water, do not belong to this Table, but to Table VII., yet, inasmuch as hyposulphite of baryta, of magnesia, and of silver, are but sparingly soluble in water, it will be well to treat a portion of the substance with dilute SO_3, and apply heat, if necessary. An odour of SO_2 never fails being produced, and the liquor becomes pale yellow from the separation of sulphur which takes place, if any of these hyposulphites are present. Of course, the separated sulphur is then mixed with the sulphate produced by the sulphuric acid employed. Hyposulphite of silver, however, being a salt which is easily decomposed into a sulphuret and sulphate, silver is not likely to be met with in the compound under present consideration.

The presence of carbonic acid, sulphuretted hydrogen, sulphurous, chromic, arsenious, arsenic acids, may have been detected, both in the preliminary examination (Table I.—C.), and whilst testing for bases (Table IX., Cols. 4, 5—19—21).

Group 4 *to* 6.

c. (Cols. 5 to 6.) The black or brown precipitate produced by HS is due to the presence of a metallic sulphuret, which will therefore, more or less completely mask the production of the yellow sulphuret of arsenic which may be produced at the same time. In fact, it is necessary, if HS produces a precipitate, no matter of what colour, to test for the presence of arsenic.

d. It is clear that the object being now to detect in what state As is in the original solution, that is to say, whether it is in the state of AsO_3 or AsO_5, the operator must now use a liquor to which no SO_2 has been added, since this reagent converts AsO_5 into AsO_3, thus:

$$AsO_5 + 2SO_2 = AsO_3 + 2SO_3.$$

HS often requires a very long time to precipitate AsO_5 in the state of yellow AsS_5, and heat considerably expedites the formation of that precipitate.

Group 7 *to* 16.

e. (Cols. 8, 9.) The ruddy fumes are produced by the evolution either of nitrous acid or of bromine; the odour enables at once the operator to distinguish the one from the other, and treatment with ether, as described in the column, affords a most ready and characteristic means of identification. The fumes, when not sufficiently abundant to be distinctly perceived, are easily noticed by looking down into the tube.

f. (Col. 8.) The white precipitate produced by BaO,NO_5, in the filtrate obtained after boiling the compound in NO_5 is, of course, sulphate of baryta, a portion at least of the sulphur of the sulphuret having been converted into sulphuric acid by the oxydizing action of the NO_5 employed.

Sulphur is generally separated, and by protracted boiling it agglomerates into yellow lumps, which may be easily identified as sulphur, because, if inflamed on a platinum foil, or a knife-blade, they burn with a characteristic blue flame, and odour of sulphurous acid.

g. (Col. 9.) It is necessary to boil the liquor after addition of NO_5, because bromides are not very readily decomposed by that acid in the cold; but by boiling, the bromine is liberated, and the liquid assumes a more or less reddish-brown colour, according to the quantity of bromine present. The whole may then be cooled by immersing that part of the tube which contains the liquid into cold water, and stirring it in it, a little ether being then added, and shaken with the liquid in the tube, a layer of a more or less intense reddish-brown colour is obtained, which is a solution of the bromine in the ether employed.

h. (Cols. 11 to 16.) Sulphocyanides being destroyed by NO_5, especially after heating, sulphocyanogen cannot be detected in this group, since the compound has been treated with boiling NO_5. Sulphocyanogen, if present in the compound, will be detected in the group in which the compound is treated by HCl.

i. (Cols. 14, 15.) Bromates are distinguished from bromides not only because bromates deflagrate when heated with sugar or other combustible substances, and yield oxygen when exposed alone to a red heat, which is not the case with bromides, but also because bromide of silver has a yellow tinge, whilst bromate of silver is quite white. Another distinctive character is, that when treated by concentrated sulphuric acid, in the cold, bromates evolve only hyacinth-red fumes of bromine, whilst bromides evolve, at the same time, thick white fumes of HBr.

Group 17 *to* 21.

j. (Col. 17.) Another good test for the presence of SiO_3 consists in fusing the residue left after evaporation to dryness, and reduced to impalpable powder, with not more than about its own bulk of NaO,CO_2, when a clear bead will be obtained. Some care is required in performing this experiment, since if too much, or too little NaO,CO_2 has been used, the bead, though clear whilst hot, becomes opaque on cooling.

k. (Col. 18.) No other white precipitate can be produced in the acid solution than one of sulphate of baryta (BaO,SO_3), since the white precipitates produced in neutral solutions containing Fl—O, HO—PhO_5—BO_3, &c., by BaCl, are all soluble in an excess of HCl, and these acids will have been detected in the examination for the base of the compound in Table IX., Cols. 14 to 20.

l. (Cols. 19 to 21.) The object of the stream of HS, passed through the liquor, and the subsequent treatment with NH_4S, is for the purpose of precipitating all the heavy metallic oxydes which would interfere with the progress of the analysis in testing for PhO_5, &c. This separation of all the heavy oxydes, however, will probably have been effected at the beginning.

m. If, however, the examination for bases has shown that an earth, such as baryta, strontia, or lime, was combined with phosphoric acid, it will be necessary to proceed, not as is descibed in this Table, but as follows: To the solution in HCl, add alcohol, and then sulphuric acid. This will precipitate the earth in the state of sulphate, and the phosphoric acid will be found in the filtrate. Or to the solution of the compound in HCl, an excess of Fe_2Cl_3 is added, so that the liquor may have a dark brown colour; if this does not take place, more Fe_2Cl_3 must be poured in and a good excess of acetate of soda added. The mixture is then boiled for about ten minutes, and provided enough acetate of soda has been used, a bulky, reddish-brown precipitate of basic phosphate of iron mixed with perphosphate of iron is produced, which should be collected on a filter, well washed, and then transferred to a beaker; an excess of NH_4S is then poured over it, and the whole is left to digest in a warm place for a few hours; under this treatment the phosphate of iron is decomposed into black sulphuret of iron, which is insoluble, and in phosphate of ammonia, which, of course, is soluble; the mass is then filtered, and the filtrate is next tested for phosphoric acid by sulphate of magnesia, which will then produce a white precipitate of ammonia-phosphate of magnesia. Or a portion of the dry compound may be fused with three or four times its weight of NaO,CO_2, or KO,CO_2, and the fused mass being treated with boiling water and filtered, will leave the earth on the filter in the state of carbonate, whilst the filtrate will contain the phosphoric acid in the state of phosphate of alkali, mixed, of course, with the excess of carbonate of alkali employed.

n. (Col. 25.) All nitrates, with the exception of the three mentioned in the list given at the beginning of this work, are soluble in water. If, therefore, nitric acid is found to exist in the present examination, it must, of course, have been a nitrate of lead, of bismuth, or of mercury. *

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* See also the other processes in TABLE XVIII., Observation *i*.

TABLE XII.

Systematic Analysis of Compounds which are INSOLUBLE IN WATER but SOLUBLE IN ACIDS, and which are supposed to consist only of ONE ACID and ONE BASE, or ONE METAL and ONE NON-METALLIC BODY.

Take a portion of the substance under examination and dissolve it in only as much HCl as is necessary for the purpose.

White precipitate, or White insoluble residue.

Presence of Pb.—Hg_2O—Ag, or $\overline{Bz}$,HO, or Benzoates.

Separate by filtering, dry the precipitate on the filter, *but do not wash it*, and expose a portion of it on a strip of platinum foil to a red heat.

Acid fumes; burns, and volatilizes completely.

$\overline{Bz}$,HO. (Observation *a*.)

Confirm by boiling the rest of the residue with KO,CO_2, filter, if necessary, and *neutralize exactly* with HCl. To the liquor exactly neutralized, as just said, add solution of Fe_2Cl_3.

Very voluminous Light Brown Precipitate.

$\overline{Bz}$,HO.

See besides, Col. 11.

$\overline{Bz}$,HO.

If the examination for bases has shown the presence of METALLIC OXYDES, remove them by passing a stream of HS to supersaturation, or by treatment with NH_4S, or by both, as the case may be, and having separated the metals thus precipitated by filtering, supersaturate the filtrate with HCl, and boil until it no longer smells of HS, filter, add to the filtrate as much NH_3 as will impart to it a slight alkaline reaction, and, no matter whether this produces a precipitate or not, add an excess of SAL-AMMONIAC, and filter, if necessary.

If the examination for bases has shown the presence of EARTHS or of ALKALINE EARTHS, add an excess of KO,CO_2 to the solution, and boil for some time, filter, in order to separate the earthy carbonate produced, neutralize the filtrate with HCl (Observation *b*), but so as to leave a very slight alkaline reaction, and add thereto an excess of SAL-AMMONIAC.

To the liquor prepared, as just said, and which we will call "PREPARED SOLUTION," add, after it has become perfectly cold, some solution of CaCl, and shake the mixture well, at intervals of a few minutes. If no precipitate is thereby produced *in the cold*, boil the liquor. If no precipitate is then produced, add alcohol.

A PRECIPITATE is produced IN THE COLD, or by BOILING, or by adding ALCOHOL.

Presence of $\overline{T}$,2HO ($C_8H_4O_{10}$,2HO) — $\overline{R}$,2HO ($C_8H_4O_{10}$,2HO) — $\overline{O}$,HO (C_2O_3,HO) — $\overline{Qt}$,3HO ($C_{18}H_5O_9$,3HO) — $\overline{Me}$,3HO $C_{14}HO_{11}$,3HO) — $\overline{G}$,3HO (C_7HO_3,3HO) — $\overline{Ci}$,3HO ($C_{12}H_5O_{11}$,3HO) — $\overline{M}$,2HO ($C_2H_4O_8$,2HO).

The PRECIPITATE produced in the COLD is

White.

Presence of $\overline{T}$,2HO—$\overline{R}$,2HO—$\overline{O}$,HO—$\overline{Qt}$,3HO—$\overline{Me}$,3HO.

To a fresh portion of the "*prepared solution*," as above said, add an excess of lime-water, shake violently, and to the precipitate or turbidness produced, add an excess of sal-ammoniac, and if the precipitate is not redissolved in the cold, apply heat. (See the Observations on Col. 1 to 5, in TABLE VIII.

Black.

and the supernatant liquor is

Green.

$\overline{G}$,3HO.

Confirm by testing a fresh portion of the prepared solution with Gelatine.

O.

To another portion of the prepared and neutral solution, add Fe_2Cl_3.

Black.

$\overline{G}$,3HO.

See TABLE VIII. Col. 6.

$\overline{G}$,3HO.

PRECIPITATE REDISSOLVES.

Presence of $\overline{T}$,2HO.

To another portion of the prepared and neutral solution, as above said, add solution of CaO,SO_3.

O

$\overline{T}$,2HO.

Confirm with CaCl + KO in excess, as described

TABLE VIII. Col 1.

$\overline{T}$,2HO.

PRECIPITATE remains INSOLUBLE.

Presence of $\overline{R}$,2HO—$\overline{O}$,HO.—$\overline{Qt}$,3HO.—$\overline{Me}$,3HO.

To another portion of the prepared and neutral solution, as above said, add Fe_2Cl_3.

White Precipitate.

$\overline{R}$,2HO—$\overline{O}$,HO.

Confirm by exposing a portion of the precipitate to a red heat on platinum foil.

Odour of burnt sugar.	Acid fumes evolved.
$\overline{R}$,2HO. See TABLE VIII. Col. 2.	$\overline{O}$,HO. See TABLE VIII. Col. 3.
$\overline{R}$,2HO.	$\overline{O}$,HO.

Black.

$\overline{Qt}$,3HO.

Confirm by testing another fresh portion with SO_3.

Curdy precipitate,	and with solution of Gelatine.
Curdy precipitate.	

$\overline{Qt}$,3HO. See TABLE VIII. Col. 4.

$\overline{Qt}$,3HO.

Blood Red Colour.

$\overline{Me}$,3HO.

Confirm by adding solution of HgCl to the blood-red coloured liquor.

Not decolourized.

$\overline{Me}$,3HO. See TABLE VIII. Col. 5.

$\overline{Me}$,3HO.

NO PRECIPITATE IN THE COLD.

Presence of $\overline{Ci}$,3HO—$\overline{M}$,2HO. Boil the whole.

White Precipitate.	O.
$\overline{Ci}$,3HO. Confirm by PbO,$\overline{A}$, and boil.	$\overline{M}$,2HO. Add alcohol.
White curdy Precipitate.	White Precipitate.
$\overline{Ci}$,3HO. See TABLE VIII. Col. 7.	Confirm by PbO,$\overline{A}$, and boil.
$\overline{Ci}$,3HO.	White Clammy Precipitate.
	$\overline{M}$,2HO. See TABLE VIII. Col. 8.
	$\overline{M}$,2HO.

NO PRECIPITATE by either treatment.

Presence of $\overline{S}$,HO ($C_4H_2O_3$,HO) — $\overline{Bz}$,HO ($C_{14}H_5O_3$,HO) — $\overline{A}$,HO ($C_4H_3O_3$,HO) (Observation *c*.)

To a fresh portion of the *prepared solution, exactly neutralized*, add solution of Fe_2Cl_3.

Bulky Light Brown Precipitate.

$\overline{S}$,HO.—$\overline{Bz}$,HO.

Separate the precipitate from the supernatant liquor by decantation, add excess of NH_3 to the wet precipitate, boil and filter. Concentrate the filtrate, add alcohol thereto, and divide into two PORTIONS.

1ST PORTION.

To the first portion add BaCl.

White Precipitate.	O.
$\overline{S}$,HO.	$\overline{Bz}$,HO.

2ND PORTION.

Add a slight excess of HCl.

O.	Milkiness or White Precipitate.
$\overline{S}$,HO. See TABLE VIII. Col. 9.	$\overline{Bz}$,HO. See besides, Col. 1, and TABLE VIII. Col. 10.
$\overline{S}$,HO.	$\overline{Bz}$,HO.

Dark Red Colour.

$\overline{A}$,HO.

Boil, and leave at rest for some little time.

Reddish Brown Precipitate.

Confirm by neutralizing a portion of the solution under examination with KO, evaporate to dryness, and heat a portion of the dry residue with SO_3 in a glass test-tube.

Odour of Vinegar.

$\overline{A}$,HO. See TABLE VIII. Col. 11.

$\overline{A}$,HO.

1	2	3	4	5	6	7	8	9	10	11	12

OBSERVATIONS ON TABLE XII.

Col. 1.

a. The precipitate produced by an addition of HCl to a solution from which the metallic oxydes have not been precipitated may consist of chloride of lead, of silver, of sub-chloride of mercury, which, however, may be at once distinguished from each other by NH_3 as described in TABLE IV., mercury turning black, silver being redissolved, and lead left white by this reagent. After testing a portion of this precipitate by NH_3, as described in TABLE IV., no doubt can exist, except as to chloride of lead and benzoic acid, since benzoates are decomposed by HCl and other strong acids, but the behaviour of benzoic acid, when heated, is totally different from chloride of lead; and moreover, if the precipitate be touched with a drop of NH_4S, it will immediately turn black, if lead is present, which is not the case with benzoic acid. If the solution be very concentrated, the precipitate may be due to the separation of boracic acid. (See TABLE XIV. Observations *a.* § 2.)

Group 2 *to* 12.

b. HCl is preferable to NO_5 for neutralizing the solution, because soda, if present, will form nitrate of soda, which will interfere with the detection of succinic acid, since that acid is not precipitated by Fe_2Cl_3 in presence of NaO,NO_5.

Group 10 *to* 12.

c. All formiates being soluble in water, cannot of course exist in the compounds treated of in this Table.

TABLE XIII.

Systematic Analysis of Compounds INSOLUBLE (or nearly so) IN WATER and IN ACIDS, and which are supposed to consist of only ONE BASE AND ONE ACID, or ONE METAL AND ONE NON-METALLIC BODY.

The Compounds belonging to that class, and which are examined in this Table, are:—

Black.	White.	Vermillion.	Purplish Red.	Brick Red.	Drab.	Yellow.	Yellowish.	Orange Red.	Purple Black.	Brown.	Dark Green.	Various Colours, or White.
HgS obtained by precipitation. Fe_2O_3 in masses after ignition. Hg_2Cl after exposure to light. $AgCl$ ditto. Cr_2O_3 when imperfectly dry.	Hg_2Cl. BaO,SO_3. $PbCl$. SiO_3, or silicate. $AgCl$. $CaFl$. PbO,SO_3. Some acid phosphates CaO,SO_3. and arseniates, after StO,SO_3. ignition.	HgS obtained by sublimation, and pulverized.	HgS in masses.	Fe_2O_3, after ignition, and in powder.	Fe_2O_3,HO.	SnO_2 after ignition. Hg_2Cl when triturated. $AgCl$ when melted. AgI—AsS_3, or AsS_5.		AsS_2, or AsS_5	$AgCl$ after exposure to light. As_6S.		Cr_2O_3 after ignition.	Acid Arseniates, } after strong Do. Phosphates, } ignition. Alumina, Certain Silicates. Do. Aluminates.

If the Compound is

White,

Take a small portion of it, reduce it into very fine powder, and drench it with NH_4S. It turns

Black, or Grey.

Hg_2Cl—$AgCl$—$PbCl$—PbO,SO_3.
Put a small portion of the compound into a small test-tube, and expose it to a low red heat, with spirit lamp.

Completely volatile without fusion.	Partly volatile, fuses into	Not sensibly volatile but fuses.	Not volatile. Not fusible.
The sublimate when hot is **Yellow.** After cooling it is **White.** Hg_2Cl. Confirm by pouring some KO on the sublimate. **Black.** Fuse a small portion in a tube with NaO,CO_2, as in TAB. I.—A. Col. 17. Metallic mirror, or Globules of Hg. To detect Cl, boil the above fused mass with HO, acidify with NO_5, filter, and test filtrate with AgO,NO_5. **White, Curdy.** insoluble in water and acids, but immediately soluble in NH_3. Cl. (Obs. *a*.) Hg_2Cl.	**Yellowish** liquid, and the sublimate is **White,** both when hot and when cold, $PbCl$. Confirm by fusing with NaO,CO_2, in the reducing flame of the blow-pipe on charcoal support, Malleable Metallic Bead, which may be dissolved in NO_5, or in A,HO, filter, and test it with HS and KO,CrO_3, and other tests for lead, which see. To detect Cl, fuse a portion in test-tube with NaO,CO_2 by means of spirit lamp and blow-pipe, boil the fused mass in water, acidify with NO_5, filter, and test filtrate with AgO,NO_5. **White, Curdy** insoluble in HO and in acids, soluble in NH_3. Cl. (Observ. *b*.) $PbCl$.	$AgCl$. Confirm by fusing a small portion of the compound with about four times its weight of NaO,CO_2 in a glass test-tube with spirit lamp urged by blow-pipe. Treat the fused mass with HO, filter, acidify with NO_5, and test with AgO,NO_5. **White, Curdy** insoluble in HO. and in acids, immediately soluble in NH_3. Cl. Boil the insoluble portion of the fused mass in the filter with pure NO_5, filter, and to the filtrate add HCl. **White, Curdy** insoluble in water and in acids, immediately soluble in NH_3. $AgCl$. (Observ. *c*.) $AgCl$.	PbO,SO_3. Confirm by fusing a portion of the compound with about four times its weight of NaO,CO_3 in reducing flame of blow-pipe on charcoal. Malleable Mettalic Bead. Pb. Identify by dissolving the bead in NO_5, or A,HO, and test the solution with HS and KO,CrO_3 and other tests for lead, which see. To detect SO_3 fuse a portion of the compound with NaO,CO_2 by flame of spirit lamp urged by blow-pipe in small test-tube, treat fused mass with water, acidify with HCl, filter, and test the filtrate with BaCl. **White,** insoluble in water and in acids. SO_3. (Observ. *d*.) PbO,SO_3.

Remains White.

CaO,SO_3—StO,SO_3—BaO,SO_3—SiO_3—CaFl.

Boil a portion of the compound well pulverized with about 500 times its weight of water, filter and divide into two portions.

1ST PORTION add thereto some BaCl.

White, insoluble in water and in acids. SO_3.

2ND PORTION add thereto $NH_4O,\bar{O}$

White, insoluble in water. Ca, therefore CaO,SO_3 (Obs. *e*.) CaO,SO_3

Mix intimately a portion of the well pulverized compound with about four times its weight of $NaO,CO_2 + KO,CO_2$ in a small platinum crucible or capsule (Observ. *f*), fuse it well therein, and treat the fused mass with hot water.

Dissolves completely. SiO_3. Supersaturate the solution with HCl, evaporate to dryness, drench the dry residue with concentrated HCl, and boil with HO.

White gritty insoluble Powder. Confirm by fusing with NaO,CO_2 in small platinum capsule before the blow-pipe, as described in TAB. XI., Col. 17. (Obs. *g*.) SiO_3

A White residue is left. StO,SO_3—BaO,SO_3. Separate the liquid from the residue by filtering, supersaturate the filtrate with HCl, and test with BaCl.

White Precipitate. insoluble in water and in acids. SO_3. Wash now the residue, dissolve it on the filter with HCl, and add a solution of CaO,SO_3 to the liquor.

White Precipitate. BaO—StO. Concentrate the remainder of the solution by evaporation, and test with $(2SiFl)3HFl$ —as described in TAB. X. Col. 1, 2.

White.	O.
BaO. Confirm by testing another portion of concentrated solution with $KO,2CrO_3$.	StO. Evaporate to dryness, and mix the dry residue with alcohol and inflame it.
Yellow. BaO. BaO,SO_3.	**Carmine Flame.** StO. StO,SO_3.

Mix a portion of the compound with concentrated SO_3 in a platinum crucible, and cover with glass coated with wax as described in TAB. VII., Col. 14.

Corrosion. Fl. Evaporate the SO_3 completely from the mass in the platinum crucible, treat the dry residue with boiling water, filter, and test the filtrate with $NH_4O,\bar{O}$

White Precipitate. Ca. CaFl.

Black.	Purplish.	Black or Grey.	Brown, or Reddish Brown.

Take a small portion of the compound, and triturate it into fine powder, if in doing so it becomes

Red, HgS. or Fe_2O_3. See accordingly, Col. 17 and Col. 18. HgS. Fe_2O_3.

Black, or Brown, or Reddish Brown.

HgS—Fe_2O_3—Hg_2Cl—$AgCl$—Cr_2O_3—C.
Put a small portion of the compound in a glass test-tube and expose it to the heat of a spirit lamp.

Volatilises completely without fusion.		Does not Volatilize.	
		Fuses	Does not Fuse.
But the sublimate whilst hot is **Yellowish,** and when cold **White.** Hg_2Cl. Confirm as directed in Col. 1.	But before doing so it turns **Black.** There is an odour of SO_2 evolved, and the sublimate is **Black.** Boil a portion of the compound in aqua regia, dilute with water; and filter, test with BaCl. **White.** S. Mix another portion with NaO,CO_2 and heat in a glass tube, as directed, Col. 17. HgS.	$AgCl$. Confirm as directed in Col. 3. $AgCl$.	Fe_2O_3—Cr_2O_3—C. Ignite a portion of the well pulverized compound in a small platinum capsule. **Remains Black.** Fe_2O_3. Examine the compound, as directed in Col. 18. Fe_2O_3. C. Except it be graphite (black-lead) or anthracite, the mass becomes gradually consumed, leaving only a small amount of ashes; whether or not this takes place, fuse some KO,NO_5 in a test-tube, and whilst in a state of fusion, throw a little of the pulverized compound into it. Deflagration. C. C.

Becomes Green. Cr_2O_3 Go to Col. 23. Cr_2O_3

Ver. million.	Brick Red.	Drab.

HgS—Fe_2O_3—Fe_2O_3HO.
Put a small portion of the pulverized compound in a glass test-tube and expose it therein to the flame of a spirit lamp.

Purple or Black.	Unaltered
but on cooling becomes again **Red.** HgS. (Observ. *h*.) Greater heat Volatilizes.	Fuse a small portion of the compound well pulverized with about four times its weight of NaO,CO_2 in a small platinum capsule, boil the fused mass with water, acidify with HCl and test with K_2Cfy. **Blue.** Fe. Test the solution with the other reagents for iron, which see. (Obs. *j*.) Fe_2O_3.

Heated upon platinum foil burns with a blue flame, odour of SO_2 and evaporates. Confirm by mixing a portion of pulverized compound with NaO,CO_2 slightly moistened, and heat in a glass tube in the flame of spirit lamp urged by blow-pipe.

Metallic mirror which may be agglomerated into globules by rubbing with a glass rod. For the S, fuse the compound with NaO,CO_2, upon charcoal before the blow pipe, put the fused mass upon a piece of silver, and moisten with a drop of dilute HCl.

Brown Stain. (Observ. *i*.) HgS.

Yellow.	Yellowish.	Orange.

AsS_3 or AsS_5—SnO_2—S—Hg_2Cl—$AgCl$—AgI.
Take a small portion of the compound and expose it to the heat of the spirit lamp in a test-tube.

Fuses, or Volatilizes, or both.		Does not Fuse nor Volatilize.
Hg_2Cl—$AgCl$—AgI—AsS—S.		SnO_2. Mix a portion with $NaO,CO_2 + KCy$, and fuse on charcoal support. Metallic Bead, Dissolve the bead in HCl, and test the solution with $AuCl_3$. **Purple.** SnO_2. See TAB. II.—B. (Obs. *g*.)
For $AgCl$ and Hg_2Cl, see Col. 1, 3. If the mass when fused was of a **Dark Red Colour,** and after cooling, of a **Dingy Yellow,** AgI. Confirm by dropping some SO_3 upon it. **Black.** (Obs. *k*.) AgI.	The mass in fusing becomes **Dark Red.** (Observ. *l*.) AgI—AsS or S. Mix a portion of the compound with NaO,CO_2 and heat before blow-pipe on charcoal support.	

Odour of Garlic.	O.
As. Boil another portion of the compound with NO_5, filter, and divide into two portions. 1ST PORTION, add BaCl. **White.** S. 2ND PORTION, add some AgO,NO_5, and gradually NH_3, to exact neutralization. **Light Brown.** As. See the other tests for As, —AsO_3, and Observation *f*, on Col. 17, 18; TABLE IV. AsS_3.	S. Throw another portion of the combination upon red-hot platinum foil, **Blue Flame and odour of SO_2,** evaporating without residue. Boil another portion with strong NO_5, and test with BaCl. **White,** Test another portion of the solution with HS with $NH_3 + NH_4S$ and with NH_4O,CO_2. **O.** S.

Dark Green. Cr_2O_3. The presence of Cr will have been detected in the preliminary examination, Col. 24; TAB. I.—B. namely by fusing a small portion of compound with borax on platinum hook before the blow pipe.

Green Bead. and also by fusing another small portion with about three times its weight of NaO,CO_2 in a small platinum capsule, before blowpipe.

Greenish Yellow mass. Confirm by dissolving the greenish yellow mass in boiling water, acidify with NO_5, and test with PbO, NO_5.

Yellow Ppte. Cr_2O_3.

Arseniates and Phosphates. Take a portion of the compound, well pulverized, and mix it with $NaO, CO_2 + KCy$, and heat this mixture in glass tube, as directed, for AsO_3, and in Obs. *f*, Col. 17, 18, TAB. IV

Metallic Mirror,	O.
easily volatilizes. AsO_5. Confirm by treating the part of tube containing mirror with fuming NO_5 dilute, add excess of AgO,NO_5, as long as precipitate produced, filter, add a little more AgO,NO_5 to filtrate, and then carefully, NH_3, nearly to saturation. **Light Brown.** See the Obs. on Col. 17, 18; TAB. IV. To detect the base, fuse a portion of compound, well pulverized, with about four times its own weight of NaO,CO_2, in a platinum crucible for half an hour; when cold dissolve in boiling water, filter, and supersaturate the filtrate with HCl, and test the solution as directed in TABLE IX. and following. AsO_5.	Put a small portion of the compound, well pulverized, into a glass test-tube, heat it by spirit lamp, to expel all moisture, drop over it a small globule of K, and cautiously heat the whole red hot by spirit lamp empty the contents of the tube on a slab, or small capsule, and breathe over it. Odour of Onion. PhO_5. To detect the base, use a portion of the compound in NaO,CO_2, as said in Col. 24, dissolve, saturate with HCl, and test as directed in TABLE IX. and following. (Observ. *m*.) PhO_5.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

OBSERVATIONS ON TABLE XIII.

The preliminary observations made on TABLE I. will have identified most of the substances treated of in the present Table.

Group 1 *to* 4.

a. (Col. 1.) The detection of chlorine in Hg_2Cl is infallible if the operator follows the directions given in this column. In fusing Hg_2Cl with NaO,CO_2, the mass, under the first impression of the heat, becomes dark reddish-brown, and when fused it is white. This effect is due to the presence of reduced mercury, which at the end volatilizes, and condenses in the metallic state on the cold sides of the tube, in the shape of a metallic ring, which may be agglomerated into globules of mercury by rubbing it with a moistened glass rod. The white mass contains the chlorine of the Hg_2Cl, in the state, of course, of chloride of sodium (NaCl). The change of colour which takes place is of itself a characteristic reaction, by which Hg_2Cl may be distinguished from HgCl, the former remaining white when mixed with NaO,CO_2 in the cold, and turning brown only when heated; whilst the latter becomes reddish-brown at once, when mixed in the cold with NaO,CO_2. But HgCl forms no part of the present examination, since it is soluble in water.

b. (Col. 2.) Forasmuch as PbCl is soluble in water *to some extent*, the operator may also boil a small portion of the compound in about 400 times its weight of water, and test the solution in the usual way for lead, by HS, which will produce a black precipitate, and by $KO,2CrO_3$, which will produce a yellow precipitate; and for chlorine by first precipitating all the lead by excess of solution of NaO,CO_2, or by HS, filtering, acidifying with NO_5, and testing with AgO,NO_5, which will produce the characteristic white curdy precipitate (AgCl), immediately soluble in NH_3, and therefore indicates the presence of Cl.

c. (Col. 3.) The presence of chloride of silver in the compound will have been detected besides, in the Preliminary Examination, TABLE I.—B., Col. 12, when a metallic bead of silver will have been obtained, in fusing with NaO,CO_2 upon a charcoal support. The present operation is substantially the same: the reduction of the metal takes place in the tube, instead of upon charcoal, and if the operator looks carefully for it, he will perceive a quantity of small silver globules mixed with the fused mass, which contains, of course, the chlorine of the chloride of silver, in the state of chloride of sodium.

d. (Col. 4.) Another excellent test for the presence of lead, in the state of *sulphate of lead*, is as follows: After having obtained a bead of metallic lead by fusing the mixture of the compound with NaO,CO_2, on charcoal before the blow-pipe, take the scories, or, if they have sunk into the charcoal, scoop out the charcoal at the place where the scories have sunk in, and place the mass upon a piece of bright silver, such as a shilling-piece for example, moisten with a drop or two of dilute HCl, a brown or black stain will be produced on the silver, and an odour of HS evolved at the same time. All sulphates give this reaction. The reduced lead may, of course, be dissolved in NO_5, or in $\overline{A},HO$, and the solution submitted to the appropriate tests described in the Dictionary.

Group 5 *to* 9.

e. (Col. 5.) It is absolutely necessary to test the solution, both for lime and for sulphuric acid, not only because it is well to ascertain the presence of both constituents beyond doubt, but also because sulphate of strontia, not being quite insoluble in water, the testing of the solution by BaCl would, of course, produce a precipitate of sulphate of baryta, which might be due to the presence of sulphate of strontia. Sulphate of baryta is perfectly insoluble in water. The operator is directed to boil the compound with about 500 times its weight of water, because CaO,SO_3 is soluble in about that quantity of water; but it is evident that if an excess of the compound is used, it will be sufficient to filter it, and the filtrate, being then a saturated solution of sulphate of lime, is ready to be tested for both lime and sulphuric acid, as directed in the column. Sulphate of lime is scarcely more soluble in hot than in cold water. The presence of sulphuric acid may also be demonstrated in the dry way, as for sulphate of lead, namely, by fusion with NaO,CO_2, on a charcoal support before the blow-pipe, as just mentioned in Observation *d.*

f. (Col. 6.) Before fusing the compound with NaO,CO_2 in a platinum capsule, make sure, as directed in Cols. 1 to 4, that the compound contains neither silver nor lead, for otherwise a hole will be made in the capsule. When a metal is present, a porcelain crucible must be used, instead of one of platinum. If the pulverized compound turned black when drenched with NH_4S, it is a sign that a metal is present, and, therefore a porcelain crucible should be employed. *

g. (Col. 6.) The compound may be a silicate, in which case the base with which the silicic acid was combined, existing now in the hydrochloric acid solution filtered from the silica, may be detected by examining that solution, according to the directions given in Table IX. and following.

Group 17, 18.

h. (Col. 17.) Vermilion, sulphuret of mercury (HgS), when exposed to a moderate heat, becomes purple or black, and reassumes the red colour on cooling, provided the heat has not been sufficient to drive away any sulphur, for, in that case, its colour, on cooling, is a dingy red, or it may even remain black.

i. As to the detection of the sulphur in HgS, the compound, instead of being fused upon charcoal with NaO,CO_2, as mentioned in this column, may be boiled with aqua regia, and the liquor may then be tested with BaCl, as already alluded to in Col. 12.

j. (Col. 18.) Fe_2O_3 is occasionally found in nature in a state in which it resists the dissolving action of acids, even after fusion with NaO,CO_2, or even with caustic KO. The best way, then, consists in mixing the compound with charcoal powder, and exposing it to a strong heat in a Hessian crucible, by which treatment the compound is reduced to the state of metallic iron. Treat now the mass with HCl, filter, and test the filtrate as usual with K_2Cfy—NH_3, and other reagents, for iron.

Group 19 *to* 22.

k. (Col. 19.) The black colour which AgI assumes, when a little concentrated SO_3 is poured upon it, is due to a liberation of iodine; by heating the mixture, violet fumes of iodine are evolved.

By fusing AgI with NaO,CO_2 or KO,CO_2, it is decomposed, and iodide of potassium, or of sodium, is formed.

l. (Cols. 20, 21.) AgI may be identified by treatment with SO_3, as just said in Col. 19, and Observations thereon.

Group 24, 25.

m. (Col. 25.) If too much potassium has been added to the insoluble phosphate, it will produce a mass which cannot be shaken from the tube, in which case, either the experiment must be repeated, or else the tube must be cut just above the fused part, which, being breathed upon, will evolve the characteristic odour of onion.

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* *f.* After having fused insoluble sulphates such as BaO,SO_3 or SbO,SO_3, &c., with an alkaline carbonate, the fused mass must absolutely be treated with water, and not with an acid, for the reasons explained in the Dictionary of Reagents, page 229.

By fusion with NaO,CO_2 the earthy sulphate is decomposed, the carbonic acid of the carbonate and the sulphuric acid of the sulphate transpose, sulphate of soda, and an earthy carbonate being produced. In treating the fused mass by hot water, the sulphate of soda being soluble, will be found in the filtrate, whilst the earthy carbonate being insoluble in water, will remain on the filter. It is therefore absolutely necessary to treat the mass by hot water, as described; for if, instead of proceeding in this manner, the operator were to attempt to dissolve the fused mass by pouring dilute HCl upon it, as inadvertently described in some books of analysis, he would reproduce the original earthy sulphate, under disengagement, of course, of carbonic acid; the filtrate would contain chloride of sodium, and the insoluble residue on the filter would be precisely the very same sulphate which had been decomposed and transformed into a carbonate by the fusion with the NaO,CO_2, but which an unlucky manipulation has reproduced, and which will have to be fused again, as at the outset.

TABLE XIV.

Systematic Analysis of MIXED COMPOUNDS which are SOLUBLE IN WATER.

Take from twenty-five to fifty grains of the compound, previously well pulverized (*if necessary*) (Observation *a* on TABLE I.—D. and TABLE II.—A.) in an agate mortar, and treat it with water, as directed in TABLE I.—D. If the compound is already in a state of solution, ascertain whether it has an acid, a neutral, or an alkaline reaction, as directed in TABLE III., and proceed as follows: Read attentively the General Observations on the Analysis of Complex Compounds, at the beginning of the Observations on this Table, and likewise the Observations on the Columns as they occur. If water produces a white precipitate, Bi—Sn—Sb or Hg, or all of them, may be present. See TABLE III., Cols. 5 to 9.

The Solution has an ACID or a NEUTRAL Reaction.

Take a small portion of the *cold* solution (concentrated if necessary,) and add thereto a little HCl. (See Observations *a* to *j*, TABLE IV.)

A Precipitate is produced.

Presence of Hg_2O—PbO—AgO—(possibly, also, a basic salt of Sb in solutions of tartrate of antimony, or of emetic; $\overline{Bz}$,HO and BO_3, may also be precipitated from their solutions and combinations by HCl.)

If a precipitate is produced in the small portion submitted to the test, add more HCl to the whole solution under examination for bases as long as a precipitate is produced, and wash the precipitate twice with pure water; filter. (Observations *a, b, c.*) If silicic acid is present the liquor will filter very slowly, and it is therefore advisable to remove it by evaporation to perfect dryness in the usual way.

The Filtrate.

Examine whether the filtrate contains anything by evaporating a few drops on platinum foil, and if it does, treat as directed in TABLE XV.

BO_3.

The Precipitate.

Take a portion of the precipitate, add thereto some alcohol, or wood-naptha, heat the capsule containing the mixture gently and inflame the vapour.

Green Flame.

BO_3.

Pour upon the precipitate an excess of NH_3.

Dissolves completely.

AgO—$\overline{Bz}$,HO. Divide the ammoniacal solution of the precipitate into two parts. (Observation *b*.)

First Portion.	Second Portion.
Neutralize exactly, add an excess of CaCl, and filter (if necessary), to this filtrate, or clear liquor, add solution of Fe_2Cl_3.	Supersaturate with NO_5.
Bulky Light Brown.	**White.**
$\overline{Bz}$,HO. The presence of this acid will be further shown in TABLE XXII.—B, Col. 14.	Insoluble in water and in acids, immediately soluble in NH_3.
$\overline{Bz}$,HO.	AgO.
	Ag.

Does NOT dissolve Completely, or AT ALL,

But the precipitate

Remains White.	Turns Black, or Grey.
Presence of PbO (and possibly AgO in solution).	Presence of Hg_2O, or of both Hg_2O and PbO (and possibly AgO in solution).

Filter.

The Filtrate.	The Precipitate is White.	The Precipitate is Black, or Grey.	
(Observation *b*.) Supersaturate the ammoniacal solution with NO_5.	PbO. Confirm by fusing a portion of the precipitate, previously mixed with NaO,CO_2, on charcoal before the blow-pipe.	Take a portion of the precipitate, mix it with some NaO,CO_2, and fuse it before the blow-pipe on a charcoal support.	Take a portion of the precipitate, mix it with NaO,CO_2, and fuse it in a small test-tube with the spirit-lamp urged by the blow-pipe.
White.	Metallic Bead.	Metallic Bead.	Globules of Hg.
Insoluble in acids and in water, immediately soluble in NH_3. Confirm by treating a portion of the precipitate as directed in TABLE XIII., Col. 3.	Malleable. Pb. Dissolve the bead in NO_5 or in $\overline{A}$,HO and submit the solution to the tests for lead.	Malleable. Pb. Dissolve the metallic bead in $\overline{A}$,HO or in NO_5, and submit the solution to the usual tests for lead.	See Observation on TABLE I.—A., Cols. 16, 17, and TABLE XIII., Col. 1.
AgO. Ag.	Pb.	Pb.	Hg_2O.

NO PRECIPITATE.

NO ODOUR.	ODOUR of SO_2.
Examine whether any fixed base is present by evaporating a few drops on platinum foil. If a residue is left, treat the solution as directed in TABLE XV.	Presence of an acid sulphite. Treat the solution for the detection of bases as directed in TABLE XV., and for acids as directed, TABLE XXI., and following.
	SO_2.

The Solution has an ALKALINE Reaction. (See TABLE III., Col. 10.) Observation *g*.

Take a small portion of the original solution, and add thereto as much HCl as will impart to it a strongly acid reaction.

NO Precipitate (or, if one is formed, it is redissolved), NO GAS, NO ODOUR.

Examine the solution as directed, TABLE XV.

The solution may contain among other substances, SiO_3–ZnO—Al_2O_3—AgCl—Sb_2O_5, and several other oxydes cyanides, and sulphurets, alluded to in TABLE III., Col. 10. See Observation *d* of this Table.

No Precipitate (or if one is formed it is redissolved), but there is an EVOLUTION OF GAS. Read attentively Observation *d*.

NO ODOUR.	ODOUR of HS.	ODOUR of HCy.	ODOUR of SO_2.
CO_2, and consequently the compound contains	Presence of a *simple alkaline sulphuret*, since a polysulphuret would have given a precipitate of S. See TABLE IV., Col. 4.	Presence of an Alkaline Cyanide. Boil until all odour of HCy has entirely disappeared, then examine the solution as in TABLE XV.	Presence of a Sulphite of Alkali. If there be a doubt as to the odour, take a fresh sample of the original solution, concentrate, if necessary, add thereto some SO_3HO, and boil.
A *Carbonate of Alkali.*	Boil the liquor with HCl, until all odour of HS has disappeared. Examine the liquor as in TABLE XV., and following.		ODOUR of SO_2. (Observation *e*.) Confirm as in TABLE VII. Col. 3. Examine the solution as in TABLE XV., and following.
All other carbonates are insoluble in water.			
CO_2.	S.	HCy.	SO_2.

A Precipitate insoluble in excess of HCl, even by boiling.

NO GAS, NO ODOUR, But the Precipitate is

White,	Yellow,	Orange.
The precipitate may consist also of BO_3. Observation *b* of this TABLE. These may be identified as described in Cols. 4 to 6. The filtrate from this precipitate, if it contains anything, is to be examined as in TABLE XV., and following.	Presence of AsS_3 AsS_5, and possibly, SnS_2, SbS. (Observation *f*.) Filter, and examine the filtrate, as in TABLE XV., and the precipitate as in TABLE XVI.	
Pb – Ag.	AsS_3—AsS_5, SnS_2—SbS.	

GAS or ODOUR is evolved. (Observation *g*)

ODOUR of SO_2 alone,	ODOUR of HS alone, and the colour of the Precipitate is Pure White, or Yellow.	ODOUR of HS alone, and the colour of the Precipitate is Otherwise Coloured.	ODOUR of HCy alone.	ODOUR of HCy and of HS.
	Ascertain that the white or yellow precipitate is pure S by exposing it to the flame of a spirit-lamp on platinum foil, in which case it will burn with its characteristic odour and blue flame.	Presence of a sulphosalt, that is, of a combination of an alkaline sulphuret with SbS—AuS_3—AsS_3—AsS_5—PtS_3 · SnS—SnS_2—and possibly, also, with HgS—CuS—NiS. (See Observations *h*, *i*.) Filter, and treat		
If an odour of SO_2 alone was evolved, a hyposulphite is present. Confirm by adding a little AgO,NO_5 to the original solution, as described in TABLE VII., Col. 4.	If an odour of HS alone was evolved, presence of a polysulphuret. Filter, and test the filtrate at once for Cr_2O_3 and Al_2O_3, as follows: Boil until all odour of HS has disappeared, when the liquor is cold add excess of KO.		Alkaline Cyanides, and possibly other Cyanides dissolved in an alkaline Cyanide. (Observation *j*.) Add an excess of HCl, and boil until all odour of HCy has disappeared; filter, and treat the liquor as at TABLE XV., and following.	Alkaline Cyanides and Alkaline Sulphurets, Sulphocyanides. Add an excess of HCl, and boil until all odour of HCy and of HS have disappeared. Filter. Treat the filtrate as at TABLE XV., and the residue (if any be left) as at TABLE XVII.
	A precipitate is produced, which redissolves in KO.			
	Al_2O_3—Cr_2O_3, and if the solution is Colourless, Al_2O_3.	Al_2O_3—Cr_2O_3, and if the solution is Greenish, Cr_2O_3 alone or with Al_2O_3.		
	Boil the potash solution for some time until the supernatant liquor is clear.			
	A Green Precipitate. Test the precipitate with microcosmic salt, or with borax, before blow-pipe.	O. Acidify the potash solution with HCl, add excess of NH_3.		
	Emerald Green.	**White.**		
S_2O_2.	CrO_3.	Al_2O_3.		

The Filtrate	The Precipitate
as at TABLE XV.	as at TABLE XVII.

OBSERVATIONS ON TABLE XIV.

QUALITATIVE ANALYSIS OF COMPLEX COMPOUNDS.

Read attentively the Observations on TABLE IV., most of which apply to this TABLE.

GENERAL OBSERVATIONS ON THE ANALYSIS OF COMPLEX COMPOUNDS.

If the substance to be examined is already in the liquid state, it will be necessary to ascertain whether it is sufficiently concentrated, whether it does not contain too large an excess of acid, or whether it does not altogether consist of free acids. If the solution be too dilute, it should first be concentrated by evaporation, since, otherwise, the precipitates or colours, instead of being produced with their characteristic appearance by the reagents employed, might be so modified in quantity, form, and hue, as to lead the operator into error, or perplexity. If there be a great excess of acid, that great excess should be expelled by evaporation, because, otherwise, the action of many reagents will be thereby prevented.

The means of ascertaining whether a free acid is present have been already alluded to in the Observations on Col. 3, TABLE III. Yet the operator will bear in mind that, in evaporating by heat the excess of acid which may be present, several substances may either be dissipated, or else undergo change, and be converted, for example, from a sub-salt into a per-salt, so that a separate examination of the original liquid becomes necessary when such an operation has been resorted to, the excess of acid being in such cases frequently neutralized by NH_3, or some other alkali, as will be shown further on.

In the general observations on qualitative analysis we have given the manner of ascertaining whether a substance is soluble in any menstruum, and the precautions which it is necessary to take in dissolving a compound and in submitting it to the action of reagents; we have only to add here, that the liquor, or solution, should always be divided into three portions, one of which is employed for the examinations of bases, the other for acids, and the third, which need not be so large as the two others, is kept for special testing.

A small portion only of the solution should be taken with each general reagent, and it is only when the reagent produces a precipitate that *the rest of the solution* is to be submitted to its action, which must be continued as long as any precipitate is produced. This is ascertained by filtering a portion of the liquid, and testing the filtrate. If the reagent produces a precipitate or turbidness in the filtrate, it is a sign, of course, that all that it can precipitate is not yet eliminated, and, therefore, more of it must be added.* *This testing of the filtrate should never be omitted*, for unless the operator most scrupulously removes all that which any of the reagents employed for the purpose can precipitate, the most inextricable confusion will ensue.

When a reagent fails in producing, in the small portion submitted to trial, the effect due to its use, the rest of the solution is to be treated exactly as if it were a liquor filtered from a precipitate which that reagent might have produced.

Before testing for acids, all the bases, except the alkalies, and alkaline earths should be removed. This is done by passing first a stream of HS through the solution to supersaturation, filtering if necessary, and then adding an excess of NH_3 and NH_4S to the filtrate until the reagents fail in producing a precipitate. If a precipitate has been produced it must be separated by filtering. A slight excess of an acid (HCl or NO_5) is then added to the filtrate, and the whole is boiled until all odour of HS has disappeared. The liquor is then in a fit state to be examined for acids.

If HS and NH_4S, or either of them, have failed in producing a precipitate, the liquor is to be treated as if it were the filtrates resulting from the separation of the precipitates which these reagents might or would have produced had substances on which they can act been present.

Group 1 *to* 8.

a.†If lead, silver, or a sub-salt of mercury be present, HCl will produce a white precipitate, which is a chloride of these bases, but whereas chloride of lead is, to a certain extent, soluble in water, and more so in pure water than in water which contains HCl, it is evident that the washing must not be continued too long, or else the precipitate, if it contains, or is, chloride of lead (PbCl), will be completely redissolved; at any rate, the filtrate is then sure to contain chloride of lead, and will therefore afford a black or a brown precipitate when subsequently treated by HS. If the solution is too dilute, HCl will evidently fail also in producing a precipitate, although a salt of lead may be present, and especially if the solution be hot, since chloride of lead is more soluble in hot than in cold water. About 33 parts of boiling water, or 155 parts of cold water, are necessary to dissolve 1 part of chloride of lead. If, therefore, the solution containing only a small proportion of a salt of lead is hot when HCl is added, no precipitate will be produced, but if allowed to cool, a white precipitate, consisting of small acicular hexaedral crystals, or of micaceous-looking plates, will be deposited. If the solution is too dilute and cold, nothing will be produced by HCl, but, of course, HS will give a black precipitate, or, if too dilute, a brown colour. The solubility of chloride of lead in water is, however, much diminished by the presence of chloride of calcium, so much so, that a concentrated solution of chloride of lead is immediately precipitated by one of chloride of calcium. †

Boracic acid is precipitated by HCl only when the solution is in a very concentrated state, and in the cold, or after the solution has cooled; its presence can at once be identified by adding alcohol to the precipitate, and inflaming the mixture, which will, in that case, produce a flame of a characteristic yellowish green colour.

b. (Col. 5.) If the solution contains both silver and lead, the addition of an excess of NH_3 will dissolve the chloride of silver, but, ordinarily, the filtrate, instead of being clear, is milky, owing to the presence of a basic chloride of lead. §

Besides Hg_2O—PbO—AgO—$\overline{Bz}$,HO and BO_3, several other substances are precipitated by HCl from acid or neutral solutions, such are silicic acid, tungstic acid, and tartrate of antimony. The compounds, which are not taken account of in this Table, will be examined in the Supplementary Tables. ‖

c. If the compound contains no other bases than Hg_2O, AgO, or PbO, do not look for CO_2—BO_3—PhO_5—SiO_3—AsO_5—AsO_3—S, since the salts which the above bases form with these acids are insoluble in water. Sulphate of silver is soluble to a certain extent (100 parts of boiling water dissolve about 1 part of sulphate of silver, and it is less soluble still in cold water).

Sulphate of lead is insoluble, or very nearly so, in water; and neutral fluoride of lead is insoluble. Read carefully, Observations *a* to *g* on TABLE IV.

Group 11 *to* 15.

d.¶In complex compounds the odour of a particular gas may be completely obliterated by the more powerful odour of another gas, which may be evolved at the same time; for example, if a carbonate and a sulphuret are present, it is clear that the evolution of carbonic acid will be imperceptible. In the same way, if the compound contains a small proportion of sulphuret and a large one of cyanide, or *vice versâ*, the odour of HS, or that of Cy predominating may mask each other's odour. We have already alluded to this circumstance in the Observations *m*, *n*, in TABLE I.—C., *e* to *i* in TABLE I.—E., and *d*, TABLE IV., the reader is referred to them.

e. (Col. 15.) This further testing of the concentrated solution of the compound by SO_3HO is for the purpose that no doubt should be left as to the odour evolved being that of SO_2, not only because sulphites are more energetically decomposed by SO_3 than by HCl (see TABLE I.—C., Cols. 13, 14), but also because when the latter acid is used, the odour of its fumes may be mistaken for those of SO_2, whilst SO_3 emitting no fumes at that temperature, the chance of error or doubt from the above cause is considerably removed.

Group 16, 17.

f. (Col. 17.) Sulphuret of antimony and sulphuret of tin are precipitated by HCl with a yellow or an orange colour, from an alkaline solution, WITHOUT ODOUR OF HS, *only when the acid employed is very dilute, or when the boiling has not been continued long enough, or when the alkaline liquid by which it is held in solution contains potash, soda, or ammonia, borax, phosphate of soda, or some other alkaline solution;* otherwise, the precipitate at first produced by HCl is accompanied by AN ODOUR OF HS. These sulphurets are soluble also in alkaline sulphurets, and in alkaline cyanides, but in the present instance, neither of these liquids can be the solvent, since the addition of HCl would produce an odour of HS, or of HCy, whilst this column refers only to a permanent precipitate produced by HCl, *without evolution of gas or of odour.* Since, therefore, the precipitate is a sulphuret thrown down by reason of the alkaline liquid which held it in solution having been supersaturated by HCl, it is to be examined as at TABLE XV., that is, as if it was a precipitate in the state of a sulphuret produced by HS.

Group 18 *to* 24.

g. We have already alluded to the circumstance of certain odours being overpowered, or masked, by others which are stronger or in greater abundance. Sulphurous acid cannot exist simultaneously with HS. If water be present at the same time, there is a deposit of sulphur and formation of water, thus: $2HS + SO_3 = 2HO + 3S$. (Observation *d.*)

h. (Cols. 21, 22.) If a precipitate of sulphur has taken place, accompanied by no other odour than that of HS, then the solution contains a polysulphuret, in which case the solution had a yellow colour, and must have shown an alkaline reaction with test-papers in the preliminary examinations. Wherefore, several substances which are insoluble in water, but soluble in polysulphurets, may be present, but then, if such is the case, the precipitate produced by HCl will not be white, the metallic sulphuret being reprecipitated with its characteristic colour, which, however, is paler, or less distinct than would otherwise be the case, because it is mixed with the sulphur resulting from the decomposition of the polysulphuret.

i. Sulphuret of mercury (HgS) is soluble in sulphuret of potassium, but insoluble in hydrosulphuret of ammonia.

Sulphuret of copper is slightly soluble in hydrosulphuret of ammonia, but insoluble in sulphuret of potassium.

Sulphuret of nickel is soluble in sulphuret of potassium, and also slightly soluble in hydrosulphuret of ammonia.

j. (Col. 23.) The solution in that case may contain not only alkaline cyanides, but also several other cyanides, which, being *insoluble in water*, are, however, more or less readily soluble in alkaline cyanides, forming numerous double cyanides, such as, for example, the ferro and ferri-cyanides.

* It is always easy to ascertain whether HS has precipitated all that it can precipitate by closing with the thumb the mouth of the flask which contains the solution after it has been submitted to the action of the gas, and shaking it violently; if the operator, while doing so, feels that his thumb is gently pushed out, and that on slightly relaxing its pressure small bubbles of gas are escaping between his thumb and the mouth of the flask, then it is a sign that the liquor is fully saturated, and it is all right; but if, on the contrary, he feels that his thumb is, as it were, sucked in after the violent shaking above alluded to, or if the liquor does not then smell strongly of HS, then the current of the gas must be continued through it for a longer time still. Recollect that a moderate heat promotes the precipitation of the sulphurets of arsenic, of tin, and of platinum.

† *a*. Solutions of tartar emetic are precipitated by HCl, by NO_5, and by SO_3; the precipitate is a basic salt, soluble in an excess of the precipitating acid and in tartaric acid.

If the solution be neutral, it is probable that it contains no other bases than alkalies, or alkaline earths, since the salts of most other bases, or metallic oxydes, have an acid reaction. Such is the case with the salts of *most*, but *not of all* other bases; for nitrate of silver, for example, reddens litmus paper *only when it contains free nitric acid.*

If the solution have an alkaline reaction, it cannot, of course, contain any of the oxydes which are precipitated by, or which are insoluble in the alkalies, a list of which will be found in the Dictionary of Reagents, under the head of each alkali. As, however, the presence of fixed organic substances modify these reactions, it is, of course, necessary to ascertain whether such substances are present or not—a circumstance which will have been already discovered, in the preliminary examinations. On the other hand, the operator should recollect, that certain metallic cyanides are soluble in alkaline cyanides, and certain metallic sulphurets in alkaline sulphurets; and these have already been alluded to in TABLE III., Col. 10.

‡ *a*. Chloride of lead may also be identified by treating the precipitate produced by HCl with hot water, filtering and adding a little dilute SO_3 to the filtered liquid whilst hot; this will produce a white precipitate of sulphate of lead, which is almost insoluble in water, but which tartrate of ammonia readily dissolves. Sulphate of lead, in fact, dissolves in all ammoniacal salts, the acid of which may form a soluble salt of lead, such are the nitrate, the citrate of ammonia, &c., and even ordinary sal-ammoniac.

The silver may also be separated in the metallic state from the two other metals by mixing the precipitated chlorides with NaO,CO_2 and heating the mass on a charcoal support before the blow-pipe. A metallic bead is thus left, which consists of lead and of silver, from which the latter metal may be extracted by cupelling, as follows:—Make a hole in a piece of charcoal and fill it with very finely pulverized bone-dust, pressing it into the cavity of the charcoal with a pestle of agate, so as to obtain a slightly concave and firm surface, place upon it the alloy of lead and of silver just alluded to, and heat it in the exterior or oxydizing flame; when all the oxyde of lead has been absorbed by the little cupel, the metallic silver will be found on its surface in the form of a small globule or rounded spangle of silver.

§ *b*. If the precipitate produced by HCl consists of Hg_2Cl, mixed with a large proportion of AgCl, the NH_3 subsequently poured upon it, instead of reducing the Hg, and thus blackening the precipitate, will dissolve both compounds. But the presence of Hg may be proved by heating a portion of the precipitate with NaO,CO_2, as described in Col. 8.

‖ *b*. Boracic acid is taken up by pouring a large quantity of water on the precipitate.

¶ *d*. Silicic acid may be recognised by evaporating to *perfect dryness*, drenching the perfectly dry residue with HCl, then boiling with water, and examining the insoluble residue which is in the state of a white gritty powder by the blow-pipe, and NaO,CO_2 in the usual way. See the Dictionary, article Silicic Acid.

Alumina, and oxyde of zinc are precipitated at first by HCl from their alkaline solutions, but they are redissolved at once by an excess of acid.

If the liquor contains NH_3 it may possibly contain AgCl, since this compound, as we have seen, is exceedingly soluble in NH_3, so that in supersaturating the liquor the AgCl would of course be re-precipitated.

As to the *sulphurets* and cyanides which may exist in the alkaline liquor, their treatment by HCl will generally evolve at once a characteristic odour.

TABLE XV.

Systematic Analysis of MIXED COMPOUNDS which are SOLUBLE IN WATER.

Treatment of the clear acidified Solution by HS.

Take a small portion of the solution of the compound acidified with HCl (or of the clear acid filtrates alluded to in TABLE XIV.), concentrated by heat if necessary, pass through it a stream of HS until the liquor smells strongly of the gas, even after violent agitation, and heat *nearly* to boiling. (Observation *a*.)

NO PRECIPITATE.

Therefore absence of all the oxydes of the first class (see Introduction), that is to say, of all the oxydes which can be precipitated by HS, consequently, absence of Cu—Ag—Hg—Pb—Bi—Au—Pt—Sb—Sn—Fe_2O_3 (when Fe_2O_3 is present, a white precipitate of S is produced) —As—Cd— and also SO_2—IrO_2—Mo—Rh_2O_3—TeO_2—PdO—Os—Va—Se—CrO_3.

Examine whether the filtrate contains anything by evaporating a few drops on a strip of platinum, and if a residue is left thereon, treat the filtrate as directed at TABLE XVIII.

A PRECIPITATE is produced.

Pass a stream of HS through the whole clear acidified solution (concentrated by heat if necessary) to supersaturation (see Observation *a*), and heat the whole *nearly* to boiling. Decant carefully the supernatant liquid in a filter, and keep this filtrate (if it contains anything) for further examination, as mentioned in Col. 2; then wash the precipitate with water until this menstruum no longer dissolves anything (which is known by evaporating a few drops on a platinum foil, or when the filtrate or supernatant liquid no longer reddens blue litmus paper), and proceed both with the filtrate first decanted and with the precipitate as follows :—

The FILTRATE.

Ascertain whether it contains anything (Observation *b*), and if it does, proceed with it as directed, TABLE XVIII. If the filtrate has a

Greenish Colour,

probable presence of CrO_3. (See TABLE IV., Col. 6, and Observations on that Column.)

CrO_3.

1 | 2

The PRECIPITATE is

Pure White.

Insoluble in excess of HCl, it is S, indicating the presence of Fe_2O_3. (Observ. *c*, *d*.)

Ascertain whether the precipitate is really S by burning it upon a strip of platinum foil, when it may be recognized by its blue flame and the odour of its fumes, and because it evaporates completely. Examine the liquor filtered from the precipitate according to the directions in TABLE XVIII The solution separated from the white precipitate of S contains now the Fe in the state of FeO. Several other substances may be present. See Col. 15, TABLE IV., and Observations on that Column.

Fe_2O_3.

3

Bluish Green.

It is S coloured by the supernatant liquid, or it is a mixture of S and of Cr_2O_3, and it indicates the presence of CrO_3. (Observat. *e*) Examine whether the precipitate is only S by burning a portion of it on platinum foil, when it may be recognized by its evaporating completely, by its blue flame and the odour of its fumes. If a residue is left on the foil, fuse a fresh portion of the precipitate with borax or microcosmic salt on platinum wire, before the blowpipe.

Emerald Green.

CrO_3.

4

Pure Yellow. (Observation *f*.) (TABLE XXIII., Observation *k*.)

Presence of AsO_3—AsO_5—SnO_2—CdO.—S (possibly also Se), perhaps, also, small quantities of Sb—Au—Pt—Hg—Pb—Cu—Bi—SnO.

Collect the well-washed precipitate on a filter, transfer a little of it to a small capsule, and pour upon it first NH_3, then an excess of NH_4S, containing a slight excess of S, and leave the whole to digest at a gentle heat for a few minutes.

Dissolves Completely. (Observation *f*.)	DOES NOT Dissolve Completely, or at all. (Observation *f*.)

Presence of As—SnO_2—S.

Take another small portion of the precipitate and expose it to a red heat on a platinum foil in the flame of a spirit-lamp.

Volatilizes Completely or partly.	Residue left.
As—S.	SnO_2.

Mix a portion of the yellow precipitate produced by HS, previously dried, with NaO,CO_2+KCy, introduce a small portion of the mixture in a small glass tube, and proceed as directed in Col. 17, TABLE IV., and Observations thereon.

Metallic Mirror.	O.
As. (Observation *g*.)	S. Boil a portion of the precipitate with strong NO_5, and test the filtrate with BaO,NO_5.
	White.
As.	S.

Mix a portion of the yellow precipitate produced by HS with NaO,CO_2+KCy, and heat before the reducing flame of blow-pipe on charcoal support.

Metallic Bead, argentine and malleable.

Dissolve the bead, *but not completely*, in HCl (Observat. *g*, TABLE II.—B.) and test the solution with $AuCl_3$

Purple.

Presence of SnO_2.

5 | 6 | 7

Presence of Cd, and possibly of As and SnO_2.

Take the rest of the yellow precipitate produced by HS, and digest the whole of it (except a small portion which should be kept for special testing) with NH_3+NH_4S, containing a slight excess of S; after a few minutes, filter.

The Filtrate	The Insoluble Yellow Residue
may contain As—SnO_2, (of course in the state of sulphurets) - S. To the clear filtrate add an excess of HCl.	CdS, and, consequently, the compound contains Cd. Mix a portion of the yellow precipitate with NaO,CO_2+KCy, and fuse before blow-pipe on charcoal support.
Yellow Precipitate.	**Brown Fumes and incrustation.**
SnS_2—AsS_3, but also S, resulting from the decomposition of NH_4S by HCl. Test a portion of the reserved precipitate as directed in Cols 5, 6, 7.	Cd.
	Cd.

8 | 9

Orange Red. | **Yellowish Orange.**

Sb, and possibly SnO_2—AsO_3—AsO_5—CdO, perhaps, also, SnO—Au—Pt—Hg—Pb—Cu—Bi.

Collect the well washed precipitate on a filter, transfer a little of it to a small capsule, and pour upon it some NH_4S, containing a little excess of S, leave the whole to digest for a few minutes at a gentle heat.

Dissolves Completely.	Does NOT Dissolve Completely, or at all.
Sb—As—SnO_2. Digest the whole of the precipitate produced by HS in NH_4S, as was done with the sample, until all is dissolved, and treat the solution as directed, TABLE XVI. The presence of As and of Sn may, however, be immediately ascertained by treating a portion of the precipitate as directed in Cols. 5 and 7. (Observation *i*)	Cd, probably mixed with Sb, and possibly also with As and SnO_2, in the state of sulphuret, of course. Digest the whole of the precipitate produced by HS in NH_4S, as above said, at a gentle heat, for about a quarter of an hour, decant the supernatant liquor in a filter. (Observation *h*.)

The Filtrate.	The Insoluble Yellow Residue
Ascertain whether anything has been dissolved, in the usual way, or by supersaturating a portion of it with HCl.	is CdS, and, consequently, presence of Cd. Confirm by treating a portion of this precipitate with NaO,CO_2+KCy, as directed, Col. 9.
Orange Red. | **Yellowish Orange.**	
Reprecipitated. Sb—As—Sn may be present. Examine the rest of the solution of the precipitate as directed in TABLE XVI.	Cd.

10 | 11 | 12

Brown, | Black, | or any other Colour.

Presence of SnO—Au—Pt—Hg—Pb—Cu—Bi, but, possibly, also As—SnO_2—Sb—Cd—Cr_2O_3—S (possibly, also, Ir—Mo—Rh—Te—Pd—Os—Va).

Collect the well-washed precipitate on a filter, and transfer a little of it to a small capsule, digest it therein for a few minutes with NH_4S, containing a slight excess of S, with the help of a gentle heat. (Observation *h*.)

Dissolves Completely.	Does Not Dissolve Completely, or at all.
Observation *i*. Presence of SnO—Au—Pt, but, possibly, also, As—SnO_2—Sb. Add to the whole precipitate a sufficient quantity of NH_4S to dissolve it after digestion with the help of a gentle heat, and keep the solution for examination, as in TABLE XVI. (Observat. *h*.)	If it dissolves partially, digest the whole of the precipitate in NH_4S, containing a little excess of S, and after about a quarter of an hour, decant the superincumbent liquor on a filter (if it does not dissolve at all, treat the precipitate as at TABLE XVII.)

The Filtrate.	The Insoluble Brown or Black Residue.
Observation *i*. To a portion of the filtrate add an excess of HCl. If a precipitate is produced, presence of As—Sn—Au—Pt—Sb—S, alone or jointly. (Obs. *j*) Examine this filtrate as directed, TABLE XVI. The presence of As and Sn may at once be detected by treating a portion of the precipitate as directed in Cols. 5—7.	Pb—Bi—Cu—Hg—Ag, and possibly Cd. Wash thoroughly with water (this brown or black precipitate or residue) and examine it as directed in TABLE XVII.

13 | 14 | 15

OBSERVATIONS ON TABLE XV.

a. We have given in Observations, Cols. 5 to 19, TABLE IV., the necessary directions in reference to the treatment of the solution by HS; the reader is referred thereto. *

If the precipitate produced by HS is yellow, and *has not appeared till the liquor was heated*, it is *probably* sulphuret of arsenic, resulting from the presence of arsenious, or of arsenic acid.

Group 2.

b. (Col. 2.) Before the liquor which has been saturated with HS, and filtered from the precipitate produced by that reagent in the clear acid liquor, is set aside for further examination, the operator will do well to put it in a warm place, in order that the arsenic, if any is present, may be thus precipitated; and perhaps he will do well to add to a portion of it some SO_2, in order to convert any arsenic acid which the filtrate may contain into arsenious acid, which is much more readily precipitated. See Arsenic Acid in the Dictionary.

Group 3.

c. (Col. 3.) Besides Fe_2O_3 several other substances have the power of decomposing HS and of separating sulphur in the state of a milk-white precipitate, such are Mn_2O_3—MnO_2—MnO_3—Mn_2O_7—CrO_3, (when they have not been previously decomposed by HCl), S_2O_2—SO_2—ClO_5—BrO_5—IO_5, and the solutions of the salts of their acids after they have been decomposed by an acid. See, besides, TABLE IV., Cols. 6—15, and Observations thereon.

d. Fe_2O_3 may be present in a solution, and yet the operator may be unable to perceive that a white precipitate has taken place. This occurs when other sulphurets are precipitated at the same time by HS. Sulphur alone is easily enough identified, but when mixed with a precipitated sulphuret, free sulphur cannot be recognized by qualitative analysis.

Group 4.

e. (Col. 4.) The liquor which is filtered from the sulphur after the reduction of chromic acid to the state of oxyde of chromium (Cr_2O_3) by the stream of HS, contains a great deal of SO_3, produced by the reaction thus—

$$4CrO_3 + 3HS = 2S + SO_3 + 2Cr_2O_3,$$

regard must, therefore, be had subsequently to this circumstance in the investigation for acids. The liquor which is filtered from the sulphur thus separated is green, and behaves towards reagents like a solution of oxyde of chromium. The precipitate consists of S and Cr_2O_3 *only when the liquor in which it has been produced does not contain enough HCl;* by adding more acid, the oxyde of chromium is entirely dissolved, and nothing is left but sulphur, easily identified as such.

Group 5 *to* 9.

f. The operator will sometimes be puzzled to decide whether or not the precipitate produced is or is not of a *pure yellow* colour, the more especially as very notable quantities even of Hg or of other black precipitates do not materially alter the hue of the colour, except by comparison. Unless, therefore, the operator has reason to know that nothing else than arsenic, per-oxyde of tin, or cadmium, are present, he will do well to examine the precipitate as directed from Columns 10 to 15. †

g. (Col. 5.) If the yellow precipitate is nothing else than sulphuret of arsenic, this metalloid existed in the compound in the state of arsenite, or of arseniate of an alkali only, since all the other compounds of arsenic are insoluble, or nearly so, in water. The operator in such a case may therefore test at once for the alkalies. ‡

The manner of distinguishing arsenious from arsenic acid is given in TABLE XVI., Cols. 2, 3.

In ascertaining whether the precipitate produced by HS is soluble in NH_4S, a pretty large quantity of this reagent must be used.

h. (Cols. 11, 12.) In order to make sure that all that is soluble in NH_4S has been taken up, more NH_4S should be poured upon the insoluble substance, and after digestion for about a quarter of an hour, the supernatant liquor is decanted into a filter, and the insoluble precipitate, if any is left, should again and again be thus treated.

Among the sulphurets which are soluble in NH_4S, protosulphuret of tin (SnS) is that which resists dissolving most, and a very large quantity of NH_4S is often necessary to take up the brown SnS left. It is, however, much more soluble in NH_4S which contains an excess of S, § wherefore, the apparently insoluble brown precipitate should be digested in hydrosulphuret of ammonia, in which a little well-washed flowers of sulphur have been dissolved.

Group 13 *to* 15.

i. (Cols. 13, 14.) If the filtrate from the digestion of the precipitate in NH_4S has a brownish or blackish colour, it is possible that copper may be present in the solution, in which case, sulphuret of potassium or of sodium should be used instead of NH_4S.

j. (Col. 14.) If the precipitate reproduced by HCl in the filtrate, being neither orange red, yellowish orange, nor yellow, is white, or if a milkiness is produced, it is *sulphur*, which is due to the decomposition of the hydro-sulphuret of ammonia, or to that which was held in solution by this reagent, and no arsenic, antimony, tin, gold, or platinum are present in the filtrate.

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* *a.* The aqueous solution should simply be acidified, that is to say the operator should not use a large quantity of acid; yet, if HCl produces a precipitate, it should be added to the solution until all that it can precipitate has fallen down, that is to say until the last drop poured into it fails in rendering it turbid.

† *f.* When the precipitated sulphuret is one which is soluble in NH_4S, there can be no difficulty in ascertaining the fact, for the operator can at once perceive that the precipitate has disappeared; but when the precipitate is a mixture of sulphurets some of which only may be soluble in NH_4S, the operator may experience some doubt as to whether a portion of these has really dissolved. The process for ascertaining this point is as follows: leave the precipitate to digest with the excess of NH_4S at a gentle heat (without boiling) for about ten minutes, dilute with water and filter. To the filtrate add an excess of HCl, if only a milkiness or a white precipitate is produced the NH_4S has dissolved nothing, if, on the contrary, a flocculent precipitate is reproduced, *of no matter what colour*, the operator may be certain that something has been dissolved by the NH_4S employed. It sometimes happens that the excess of HCl thus employed to supersaturate the NH_4S produces only flakes of a light drab colour, this is generally or very frequently due to the presence of a little copper, the sulphuret of this metal being slightly soluble in NH_4S, wherefore KS or NaS is preferable in such a case. The presence of copper in this reproduced precipitate may be identified by treating it with a little NO_5, boiling in order to agglomerate the sulphur into yellow lumps, diluting with water, filtering and supersaturating the filtrate with NH_3, the solution will then assume a characteristic blue colour. The excess of NH_3 may further be supersaturated with $\bar{A}$,HO, and a drop of K_2Cfy added to the liquor will produce also a characteristic crimson precipitate or colour, if Cu is present.

‡ *g.* Always supposing that the compounds contain no bases capable of being precipitated by NH_4S, or by (2NaO), HO,PhO_5.

§ *h.* The protosulphuret being thereby converted into bisulphuret of tin (SnS_2) which is much more soluble.

TABLE XVI.

Systematic Analysis of MIXED COMPOUNDS which are SOLUBLE IN WATER.

Treatment of the Solution in NH_4S of the Precipitates produced by HS, and of the liquors filtered from the Insoluble Precipitates, and alluded to in the preceding Table.

The solution in NH_4S and the filtrates may contain S—As—Sn—Sb—Au—Pt. (Possibly also Ir.—Se—W.—V. Mo—Te. See the Supplementary Tables.)

Take the Solution in NH_4S of the Precipitate produced by HS, in TABLE XV., and if the whole of that Precipitate was not disssolved by that reagent, take the liquors filtered from that insoluble portion, mix all the filtrates together, dilute, if necessary, with water, and add thereto a slight excess of HCl, so as to impart to it a strongly acid reaction, and apply heat. (Observation *a*.) If the Precipitate produced is—

White or Milky,

It is S.

Ascertain that it is S, by igniting on a strip of platinum. If it burns with a blue flame, and with a characteristic odour of SO_2, it is S, resulting from the decomposition of the reagent (NH_4S) by HCl, or of that which may have been precipitated by treatment with HS (see Col. 3, TAB. XV.) and which has been dissolved by the NH_4S employed.

S.

1

Pure Yellow.

Presence of As—SnO_2, or both. (Observation *b*.)

Treat a portion of the precipitate exactly as described in TABLE XV., Col. 5—7, that is to say, by heating it on a strip of platinum foil.

Volatilizes completely.

As alone is present.

Treat another portion of the well washed and well dried precipitate (Observ. *c*.) with about five or six times its weight of equal parts of NaO,CO_2 and of KCy.

Metallic Mirror.

Odour of Garlic.

As.

To ascertain whether As existed in the solution, as AsO_3 or AsO_5, pass a stream of HS through a portion of the original solution *until all is precipitated*. Separate the precipitate, and add to it an excess of NH_3, by which the AsS produced is redissolved, filter, if necessary, add to the liquor, or filtrate, an excess of AgO,NO_5, filter to separate the black precipitate of AgS produced, and supersaturate the filtrate with dilute NO_5; if a white precipitate is produced, shake and filter, and to the clear acid filtrate, add NH_3, *nearly to neutralization*.

(Observation *c*.)

Yellow,

immediately soluble in the slightest excess of NH_3 or of NO_5.

AsO_3.

AsO_3.

2

Light Brown,

immediately soluble in the slightest excess of NH_3 or of NO_5.

AsO_5.

AsO_5.

3

Residue is left.

SnO_2, but possibly also AsO_3 or AsO_5.

If the volatilization is almost complete the precipitate is chiefly AsS_3 or AsS_5.

Treat another portion of the yellow precipitate with NaO,CO_2 + KCy, as directed in TABLE IV., Col. 17, to obtain

MetallicMirror.

Odour of Garlic

The presence of As may also be ascertained, as directed in Col. 7, that is, by treating the yellow precipitate with fuming NO_5, &c.

To ascertain whether As existed in the solution, as AsO_3 or AsO_5, proceed as directed, Col. 2, 3.

AsO_3.
AsO_5.

4

Treat another portion of the yellow precipitate with NaO,CO_2 + KCy on charcoal before the reducing flame of blow-pipe.

Malleable Metallic Bead, looking like silver.

easily oxydizable in the oxydizing or outer flame.

Sn.

Confirm by dissolving this metallic bead in HCl *without heat*, and test with $AuCl_3$. See TABLE II.—B., Obs. *g*.

Purple.

Sn.

To ascertain whether it existed in the substance as SnO, or SnO_2, add a little *cold* NO_5 to the original solution. (*Do not apply heat*), and test with $AuCl_3$. (Observation *d*.)

Purple.

SnO.

5

O.

SnO_2.

6

Orange Red. | **Yellowish-Orange.**

Presence of Sb, but possibly also of Sn and As.

Dry the whole of the precipitate at a gentle heat, reduce it to powder, put it into a porcelain capsule, and cautiously pour upon it by small portions at a time, some fuming NO_5, until effervescence ceases, and nitrous fumes are no longer evolved. Evaporate to syrupy consistence, remove the yellow lumps of S produced, treat the syrupy mass with HO, and filter.

The Filtrate.

Add to the filtrate an excess of AgO,NO_5; if a white precipitate of AgCl is formed, heat to boiling, in order to agglomerate it, filter, and to the clear filtrate, add as much NH_3 as is necessary, *nearly* to neutralize it.

Light Brown.

As.

(Observ. *e*.)

As.

7

The White Insoluble Residue.

It may consist of Sb_2O_5, or of SnO_2, or of both.

Wash this white residue with water, and boil it with a strong solution of $\overline{T}$,2HO, or with a saturated solution of $KO,HO,\overline{T}$.

DISSOLVES Completely.

Sb alone.

Confirm by adding a little HCl to this $\overline{T}$,2HO solution, filter. (Observ. *f*.) if necessary, and through the clear filtrate pass a stream of HS.

Orange Red.

Sb.

(Observ. *e*.)

Sb.

8

DOES NOT DISSOLVE completely, or at all.

Filter and boil the insoluble portion with a fresh quantity of $\overline{T}$,2HO, filter.

The Filtrate.

Add a little HCl, and pass a stream of HS through it.

Orange Red.

Sb.

(Observ. *e*, *f*.)

Sb.

9

The Insoluble portion.

Dry the residue well, and mix it with NaO,CO_2 + KCy, and heat on a charcoal support before the blow-pipe.

Malleable Metallic silver-looking Bead.

Sn.

Confirm as directed.

Col. 5, 6

Sn.

10

Dark Brown, | **or Black.**

Presence of SnO—Au—Pt, but possibly also As—Sb—SnO_2.

To a small portion of the original solution add a few drops of SnCl. (Observation *g*.)

Purple Precipitate.

Au.

If the solution is dilute,

Purple Colour but no Precipitate.

Au.

To another small portion of the original solution add a few drops of FeO,SO_3.

Brownish Black, or Brown.

Au. (Obs. *h*.)

To a very concentrated portion of the original solution add a few drops of NH_4Cl and of HCl.

O.

Au.

11

Brown Colour but no Precipitate.

Pt.

If the solution is dilute,

Brown Precipitate.

Pt.

O.

Pt.

Yellow Precipitate.

Pt.

12

Dry the whole of the precipitate at a gentle heat, and treat it cautiously with fuming NO_5. Evaporate to syrupy consistence, remove the lumps of S, treat the syrupy mass with water, as directed in Col. 7 to 10, and filter.

The FILTRATE.

Add to the filtrate an excess of AgO,NO_5, and proceed exactly as described in Col. 7. If NH_3, added *nearly* to neutralization, produces a precipitate which is

Light Brown,

Presence of As.

As.

13

The INSOLUBLE RESIDUE.

Wash it well with water, and boil it with a strong solution of $\overline{T}$,2HO, or with a saturated solution of $KO,HO,\overline{T}$, exactly as in Col. 9, 10.

DISSOLVES completely.

Sb alone.

Confirm by adding a little HCl and then a stream of HS; as at Col. 8, (Observ. *e*, *f*.)

Orange Red.

Sb.

Sb.

14

DOES NOT DISSOLVE completely, or at all.

Filter, and boil the insoluble residue again with solution of $\overline{T}$,2HO, and filter.

The Filtrate.

Add thereto a little HCl, and pass through it a stream of HS. (Observ. *e*, *f*.)

Orange Red.

Sb.

Sb.

15

The Insoluble White Residue.

Dry the residue well and mix it with NaO,CO_2 + KCy, treat in the reducing flame of blow-pipe on a charcoal support.

Malleable Metallic Bead, looking like silver.

Sn.

Confirm by dissolving the bead in HCl, and test with $AuCl_3$, as in Col. 5, 6. (Observ. *d*.)

Purple Precipitate.

To ascertain whether it existed in the original solution as SnO, or SnO_2, proceed exactly as described, Col. 5, 6.

SnO.

Pt.

16

SnO_2.

Pt.

17

OBSERVATIONS ON TABLE XVI.

GENERAL REMARKS.

a. The operator will do well to compare the observations made on each column of TABLE IV., corresponding to those of the present Table, most of the said observations being equally applicable here.

The proportion of NH_4S employed should not be too large, because, on subsequently supersaturating the liquor with HCl, the quantity of S that would then separate might conceal the presence of the sulphuret dissolved by the reagent.

The metal or metals looked for are now, of course, in the state of sulphuret, or of sulphurets dissolved in NH_4S; but the precipitate produced by supersaturating the solution with HCl consists, not only of the sulphuret or sulphurets of the metals, but likewise of the sulphur resulting from the decomposition of the hydrosulphuret of ammonia in which they were dissolved, which admixture of sulphur renders, of course, the colour of the precipitated sulphurets less distinct than when precipitated by HS, as in the first instance.

b. AsS is completely soluble in NH_3. The yellow precipitate thus reproduced by supersaturation with HCl sometimes contains CuS, because Cu, to a certain extent, is soluble in NH_4S, and the precipitate has a more or less deep dark colour. The presence of that metal can be ascertained by heating the precipitate with a little fuming NO_5, diluting with water, filtering, adding to the filtrate an excess of NH_3, when the liquor, which may be again filtered, if necessary, will exhibit a characteristic blue colour; or if the quantity of copper present is too small to yield this reaction, supersaturate the NH_3 of the liquor with $\overline{A},HO$, and test with K_2Cfy, a crimson precipitate, or pink colour, will then be produced. When the precipitate contains any notable quantity of copper, it has a dingy or drabby hue, instead of a pure yellow colour.*

Group 2 *to* 5.

c. (Col. 2, 3.) On treating the newly precipitated yellow sulphuret of arsenic by NH_3, it will be redissolved, and on subsequently adding AgO,NO_5, the Ag is precipitated in the state of black sulphuret of silver (AgS), which the operator separates by filtering. If now the clear ammoniacal liquor, which contains an excess of the AgO,NO_5 employed, be *exactly neutralized* with dilute NO_5, the characteristic yellow basic arsenite, or light brown basic arseniate of silver, will be at once produced. If, however, the solution contains any HCl, a white precipitate of chloride of silver will appear; in that case a slight excess of dilute NO_5 should be poured in, and then a little more AgO,NO_5 than is sufficient to eliminate the whole of the HCl. The white precipitate of chloride of silver produced should then be separated by filtering, and a portion of the acid filtrate transferred to a test-tube. The test-tube should now be held slantingly, and a few drops of ammonia poured in, so as to run down the sides. Thus carefully poured, the ammonia will be seen floating over the acid liquor, and at the point of contact the characteristic yellow or brown precipitate of arsenite, or of arseniate of silver, will immediately, or in a short time, appear. If ammonia be carefully added, only in such quantity as *nearly* to neutralize the liquor, the precipitate produced will become permanent. If too much ammonia has been added for the purpose, the precipitate will immediately be redissolved; but the excess of ammonia may be neutralized with a few drops of NO_5, when the precipitate will reappear. †

d. (Col. 5, 6.) The precipitate produced by HS in proto-salts of tin being brown, and that produced in per-salts of the same subsistence being yellow, the two may easily be distinguished from each other when the solution does not contain other metals which are precipitated black or brown by HS, in which case, the colour of the yellow sulphuret will be masked; but both sulphurets of tin (the brown and the yellow) being soluble in NH_4S, they could be distinguished from each other by supersaturating the solution with HCl, if they were thereby reprecipitated with their characteristic colour; *this, however, is not the case;* when an excess of HCl is poured in the solution of protosulphuret of tin (SnS) in NH_4S, it is always reprecipitated therefrom in the state of bisulphuret of tin (SnS_2), which is yellow, and hence the necessity of testing the original solution specially, for the purpose of ascertaining whether the tin existed in the state of a proto-salt or a per-salt.

The use of the *cold* nitric acid is for the purpose of converting a small portion of the proto-salt of tin into a per-salt, since $AuCl_3$ does not produce the characteristic deep purple precipitate, unless some per-salt of tin be present, a trace of which, however, is sufficient. Proto-salts or per-salts of tin *alone* do not produce any precipitate with $AuCl_3$. (See Observation *z*, § 2, TABLE IV.)

Group 7 *to* 10.

e. (Col. 7 to 10.) Another way of testing for arsenic, antimony, and tin, in the state of sulphurets of these metals, consists in mixing these sulphurets with their weight of equal parts of NaO,CO_2 and KO,NO_5, and projecting the mixture, by small portions at a time, into a crucible over a spirit lamp, and containing about two parts of KO,NO_5 in a state of fusion. Deflagration having taken place, the fused mass is poured upon a slab of glazed earthen ware, treated *with cold water*, and filtered. The filtrate may be then tested for As by AgO,NO_5, in the usual way (Col. 7), when a light brick-red precipitate will then appear.

It is necessary to employ *cold*, and not *hot* water, to dissolve the mass fused with NaO,CO_2, and KO,NO_5, because the anhydrous antimoniate of potash (KO,Sb_2O_5) formed (if any antimony is present), and which is *insoluble* in cold water, would be converted by boiling with that liquid into antimoniate of potash with five equivalents of water ($KO,Sb_2O_5,5HO$), which is soluble in that menstruum, so that the white mass, which at first seemed insoluble, would gradually disappear, and no other salt of antimony would be left but a very small quantity of biantimoniate of potash ($KO,2Sb_2O_5$).

The filtrate is then supersaturated with NO_5 and tested for arsenic with AgO,NO_5, exactly as described in Col. 7.

The white residue which refused to dissolve in cold water should be thoroughly washed, and then dissolved in HCl. A rod of pure zinc being now immersed into this solution in HCl, the antimony and tin, if present, will be precipitated in the shape of greyish flakes, or of a black powder. When all action has ceased, the precipitated metal being boiled with NO_5, is converted into insoluble antimonic acid and peroxyde of tin, in the shape of a white powder; the white powder being well washed, is then tested for antimony and tin, by boiling with a strong solution of $\overline{T},2HO$, exactly as described in Col. 8 and 9.

f. (Col. 8.) It is necessary to add a little HCl to the solution of antimony in tartaric acid or in bitartrate of potash, because otherwise the stream of HS would only impart a deep red colour to the liquor, but would not produce the orange-red precipitate. If, however, the solution be heated, the precipitate will appear, although no HCl may have been added, and even long standing has the same effect. This is not due exclusively to the presence of $\overline{T},2HO$, organic matters in general producing the same result, and moreover, if a solution of a salt of antimony is neutral, or very dilute, HS imparts to it a red colour, but forms no precipitate, unless a little free acid be added or heat applied.

If the solution is very concentrated, the addition of HCl will produce at first a slight precipitate, which consists of basic chloride of antimony combined with a basic tartrate of antimony, whilst a neutral tartrate of antimony and potash remains in solution. If an excess of HCl is added, no precipitate at all is produced, or that which may have at first appeared soon redissolves.

Group 11, 12.

g. In concentrated solutions of platinum SnCl produces a reddish-brown colour, but no precipitate. In dilute solutions, on the contrary, a reddish-brown precipitate is at once produced, as we have already remarked in the Observation *x*, on Col. 12, TABLE IV.

The SnCl employed should contain a little perchloride, without which no precipitate will be produced, as already said. (Obs *d*–*z*. TAB. IV. Wherefore, the reagent should be tested with $AuCl_3$, and if it does not produce the desired precipitate, it is necessary to add a drop of NO_5 to it, before using it as a test for gold.

h. (Col. 11.) If the liquor operated upon is a concentrated one, FeO,SO_3 will produce at once a dark brown, almost black, precipitate, which is pure metallic gold. If the liquor is more dilute, the addition of FeO,SO_3 at first produces only a bluish colour, but a brown precipitate soon after makes its appearance, and the surface of the liquor is generally more or less covered here and there with a brownish film, exhibiting in certain positions the metallic lustre of gold.

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* *b.* Before filtering the solution in fuming NO_5 of the precipitate, which contains a little copper and which has on that account a more or less deep drab colour, it is evident that the said solution must be diluted with water since it would otherwise corrode the filter and pass through. Sulphuret of arsenic is completely soluble in NH_3.

† *c.* Before treating the precipitate with NaO,CO_2 + KCy it is absolutely necessary that it should be well washed and dried, for if it contained a nitrate, a more or less violent detonation would take place on heating it as directed.

To discover whether the arsenic existed in the liquor in the state of arsenious or of arsenic acid the following method may be resorted to: wash thoroughly the yellow precipitate produced by HS in the solution, and boil with hydrated oxyde of bismuth, filter in order to separate the black sulphuret of bismuth produced, and divide the filtrate into two portions. To one of them add ammoniacal nitrate of silver, which of course must not contain an excess of NH_3. If a brick-red precipitate is produced it is due to the presence of arsenic acid; if a yellow precipitate, it is due to that of arsenious acid. To the second portion add a little KO in order to render it slighly alkaline, and then a few drops of CuO,SO_3, and boil the mixture. If a red precipitate of metallic copper is produced, it is a proof of the presence of an arsenite and the liquor will then contain arsenic acid, the arsenite having been converted into an arseniate with reduction of copper as just said. This reaction is very delicate, but an excess of CuO must be avoided. See also TABLE XXIII., Observation *m*.

TABLE XVII.

Systematic Analysis of MIXED COMPOUNDS which are SOLUBLE IN WATER.

Treatment of the Precipitates produced by HS, Insoluble in NH_4S. These Precipitates may be due to the presence of Cd—Cu—Ag—Pd—Pb—Bi—Os—Hg.

Wash the Precipitate thoroughly, transfer a small portion of it to a small porcelain capsule, pour upon it some pure, moderately strong NO_5, and boil the whole, stirring the mass all the while. (Observation *a*.)

THE PRECIPITATE DISSSOLVES COMPLETELY.

(Except the sulphur resulting from the decomposition of the sulphuret by boiling with NO_5, as just said, which sulphur agglomerates into yellow lumps by protracted boiling. (Observation *b*.) Except also, if lead, for example, be present, a white insoluble precipitate of PbO,SO_3, which may result from the conversion of the sulphur of the sulphuret into SO_3, by boiling it with NO_5, as just said. If, in other respects, complete solution is effected, boil the rest of the precipitate with NO_5.) (See Observ. *b*. and TABLE XXIII., Observ. *c*.)

THE PRECIPITATE DOES NOT DISSOLVE completely, or at all, a black residue being left (which is, of course, different from the yellow lumps of sulphur, or from the PbO,SO_3, resulting from the action of NO_5 upon PbS.)

If the precipitate produced by HS, insoluble in NH_4S, but soluble in NO_5, was, before being boiled with that acid, more or less—

Pure Yellow.

Cd.

Mix another portion of the yellow precipitate with NaO,CO_2+KCy, and fuse before the blow-pipe on a charcoal support.

Brown Fumes and incrustation but NO METALLIC BEAD.

Cd.

Mix another portion of the yellow precipitate with about three or four times its weight of KCy, transfer the mass to a small test tube of hard glass, and holding it horizontally, heat it in the flame of an argand spirit lamp, so as to bring it to a cherry red heat.

Metallic mirror of Cd accompanied by rings of a yellow, brown, and black colour, of anhydrous CdO.

(See TABLE XXIV. Col. 1., Obs. *a*.)

Cd.

1

Brown (more or less).

It may contain Cu—Cd—Ag—Pd—Pb—Bi—Os, &c. Filter, in order to separate the agglomerated lumps of sulphur, and possibly the PbO,SO_3, resulting from the action of NO_5 upon the precipitate of PbS, which may have been produced by HS in the original solution. (Observation *b*.) Divide the filtrate into Three Portions.

1ST PORTION.

Add to this first portion *an excess* of NH_3. (*c*.)

NO PRECIPITATE, and the liquor is—

Blue, or else Colourless. (Observation *d*.)

Acidify the clear ammoniacal liquor with $\overline{A},HO$ (filter, if necessary), and add then some K_2Cfy.

Crimson.

Cu.

If NH_3 has at once produced a blue colour, Cu is certainly present.

(Observation *e*.)

Cu.

2

To a portion of the ammoniacal filtrate, *which may be blue*, owing to the presence of copper, add an excess of NH_4O,CO_2, apply heat, and leave the whole at rest for a while. (Observ. *e*.)

White Precipitate.

Cd.

Confirm by dissolving a portion of the precipitate in HCl, and passing a stream of HS, through the solution.

Wash the precipitate well before dissolving it.

(Observation *e*.)

Yellow.

Cd.

Cd.

3

To another portion of the ammoniacal filtrate, *which may be blue* from the presence of copper, add an excess of HCl.

White Curdy Precipitate.

Insoluble in acids; immediately soluin NH_3.

Ag.

(Observation *f*.)

Ag.

4

To another portion of the ammoniacal filtrate, *which may be blue*, add as much HCl as is necessary exactly to neutralize it, filter, if necessary, and add some solution of HgCy to it.

Yellowish White,

soluble in an excess of HCl.

Pd.

(Observations *c—g*.)

Pd.

5

Precipitate is formed.

Presence of Pb—Bi—Os—but possibly also Cd—Cu—Ag—Pd.

Filter and examine the filtrate for Cu—Cd—Ag—Pd, as directed, Col. 2 to 5, (Observation *g*.)

In order to ascertain the presence of Pb—Bi—Os, test the second and third reserved portions, as directed in Col. 7 to 9.

6

Black.

2ND PORTION.

Evaporate the excess of NO_5, present in this second portion, and then add thereto an excess of (dilute) SO_3.

(Observ. *g*. § 2.)

White Precipitate

immediately, or after a short time; insoluble in acids, soluble in pure KO.

Pb.

To confirm, moisten this white precipitate with NH_4S.

The white precipitate above may also be treated as directed in Observations *b—e*.

(See TABLE XXIV., Observation *b*.)

Black.

Pb.

7

3RD PORTION.

Evaporate this third portion to dryness, and dissolve the dry mass in water containing a few drops of HCl, apply heat, and pour the liquor into a long glass cylinder, full of water.

White Precipitate, or Milkiness.

Bi.

(Observation *e*.)

Bi.

8

If while boiling the precipitate in NO_5, as directed at the beginning of this Table, a peculiar odour, resembling that of chloride of sulphur, and which excites cough, is noticed; it is due to the presence of

Os.

As soon, therefore, as this is observed, close the flask with a cork, provided with a tube, so as to condense the vapours, a solution of OsO_4 may be thus collected, and if on adding a sulphite the solution becomes

Purple-Blue.

(Observation *h*.)

Os.

Os.

9

Presence of Hg, but possibly Cd—Cu—Ag—Pd—Pb—Bi—Os may also be present, and are now in solution. Allow, therefore, the insoluble precipitate to settle well, and decant or filter the supernatant liquor, and proceed as follows:—

THE FILTRATE.

Test a portion of the filtrate by HS to supersaturation, and if a precipitate is produced, test the rest of the filtrate for Cd—Cu—Ag—Pd—Pb—Bi—Os, as directed in Col. 1 to 9.

10

THE PRECIPITATE.

Wash the precipitate thoroughly and dissolve it in a small quantity of aqua regia, add thereto NH_3, *nearly* to saturation, and put a few drops of the solution upon a strip of clean copper, wipe off, and rub the part with piece of paper or of cork.

Silver Stain.

Hg.

To confirm, if necessary, evaporate the aqua regia solution to dryness, dilute the mass with a little water, add excess of SnCl, and boil, if necessary.

Grey Powder, or Metallic Globules.

Hg.

If the original solution contained it, as Hg_2O, it will have been precipitated by HCl at the outset.

Hg.

11

OBSERVATIONS ON TABLE XVII.

a. *It is absolutely necessary to wash the precipitate thoroughly before treating it with NO_5,† because, although HgS is insoluble in moderately dilute NO_5, yet it is readily soluble in aqua regia. If, therefore, from insufficient or careless washing, the precipitate is contaminated by a chloride, or by hydrochloric acid, aqua regia will be produced, and a portion, or the whole of the HgS may be dissolved by the NO_5 employed under such circumstances. ‡

Group 1 to 9.

b. It frequently happens that the sulphur of the sulphurets cannot be agglomerated into yellow lumps, except the acid be evaporated, by boiling almost to syrupy or pasty consistence, the sulphur remaining for a long time in the state of light, insoluble, spongy-looking flakes of a blackish or greyish colour, which is due to the presence of small portions of some, as yet, undecomposed sulphuret. In such cases, if lead be present, a considerable portion of it will be sure to be converted into sulphate of lead. It is, therefore, advisable to boil the liquor until the sulphur is agglomerated into lumps of a pure yellow colour, otherwise the sulphate of lead being mixed with the deposited sulphur, might possibly be mistaken altogether for sulphur, and thus escape detection, whilst, on the contrary, there is always enough lead dissolved by the nitric acid employed, to be subsequently detected in the filtrate, and, besides, the white precipitate may be tested for lead in the usual way, that is, by NH_4S, which will turn it black, and by fusion before the blow-pipe, on a charcoal support, with NaO,CO_2 + KCy, by which a malleable metallic bead may be at once obtained. § (See TABLE XXIII., Observation *c.*)

c. If the liquor was brown and is rendered colourless by the addition of NH_3, palladium is probably present.

d. (Col. 2 to 5.) The addition of NH_3 to a clear and colourless solution may leave it apparently colourless, although copper may be present; because, although ammonia produces a very distinct and beautiful, and in this case, very characteristic blue colour with copper, yet this metal must be present in some quantity to produce a readily apparent blue colour. If only a small quantity of copper is present, the blue colour is so faint that it may escape observation altogether, especially to the unpractised eye. If, however, the solution be looked at vertically, that is to say, in the direction of the depth of the liquid, the colour may be better seen. At any rate, before concluding to the absence of copper, the operator should acidify the ammoniacal solution with $\overline{A}$,HO and test with K_2Cfy, as mentioned in Observation *r*, TABLE IV., or with a bar of iron, as mentioned in the Observation *s*, TABLE IV.

e. (Col. 3). In strongly ammoniacal solutions the presence of cadmium is not immediately rendered apparent by an addition of an excess of NH_4O,CO_2, because, as CdO is soluble in a slight excess of NH_3, this latter reagent prevents its being readily precipitated by NH_4O,CO_2, even by boiling. On neutralizing the excess of NH_3 in the liquor by HCl, a white precipitate falls down, which is CdO,CO_2 (of course, provided no AgO be present at the same time, but the latter metal would have been detected at the beginning, when acidifying the liquor with HCl). The best way, however, is to supersaturate the liquor to be tested with HCl, filtering, if necessary, adding to the clear liquor or filtrate an excess of NH_4O,CO_2, boiling for about a quarter of an hour, and allowing it to rest. If a white precipitate is then produced, it is CdO,CO_2 which may be recognized as such by re-dissolving in HCl, and passing a stream of HS through the liquor. ‖

f. (Col. 4.) If the liquor contains a large quantity of an ammoniacal salt, or, which is the same thing, if it was very acid before treatment with excess of NH_3, the supersaturation of the NH_3 by HCl may not immediately produce a white curdy precipitate, but in the course of a short time the liquor will become milky, and chloride of silver will be deposited. If a small quantity of silver is present, the liquor assumes only an opaline tinge; if, however, heat be applied, chloride of silver soon settles and the supernatant liquid is clear.

If silver, lead, or mercury are present, they will have been detected at the outset. See TABLE XIV., Col. 3 to 7.

g. (Col. 5 and 6.) If the solution contains palladium (Pd) in the state of a nitrate (PdO,NO_5) ammonia will produce no precipitate, and an excess of it will merely render the solution colourless; but if the palladium is in the state of a protochloride (PdCl), a yellowish precipitate is produced, which is a compound of ammonia with chloride of palladium ($Pd,ClNH_3$), and is almost insoluble in NH_3, except a very large excess is poured in, and even then a long time is required. Wherefore Pd appears in TABLE XVII., Cols. 5 and 6. (See TABLE XXIV., Observation *a.*)

After evaporating the excess of nitric acid of this second portion, it may happen that SO_3 will produce no precipitate in the liquor, though Pb may have been present; this is owing to the whole of the lead having been precipitated, or left as a white insoluble residue of sulphate of lead after treatment of the black sulphuret by NO_5. It will therefore be necessary to examine this white insoluble residue by the usual tests for lead. See Col. 7.

h. (Col. 9.) When osmic acid is present, the addition of a sulphite imparts to the solution a deep violet blue colour which is more permanent in dilute than in concentrated solutions. In course of time, however, this violet colour vanishes, but a black precipitate of osmium is produced.

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* *a.* If the sulphurets insoluble in NH_4S contain CuS, it is well to add a little HS or a few drops of NH_4S to the water used for washing, otherwise the CuS or a portion thereof being converted into CuO,SO_3 by the action of the air, will be disolved by the water employed for washing.

† *a.* It is necessary that the NO_5 employed should be quite free from HCl.

‡ *a.* In order to ascertain at once whether any portion of the precipitate has been dissolved by the NO_5 employed, a few drops of the liquor may be put into a glass test-tube, and if a large excess of a strong solution of HS mixed with it produces no precipitate, it is, of course, a sign that nothing has been dissolved by the NO_5. Or else a few drops of the filtrate may be evaporated in the usual way upon a strip of platinum foil—if no fixed residue is left it is also a proof that nothing has been taken up by the acid.

§ *b.* The operator may at once ascertain whether the white precipitate is PbO,SO_3 by mixing it with NaO,CO_2 and heating it upon a charcoal support before the blow-pipe, by which means a soft malleable globule of metallic lead is instantly obtained, accompanied by a yellow incrustation. This globule may be further dissolved in NO_5, and the solution submitted to the reactions indicated in the Dictionary for the identification of that metal. We also said in Observation *a*, on TABLE XIV., that sulphate of lead was readily soluble in certain ammoniacal salts, and therefore the white precipitate in question, being thoroughly washed, may also be heated with a solution of tartrate or of citrate of ammonia, by which it will be converted into tartrate or citrate of lead, with formation of sulphate of ammonia; and if this solution be then tested with $KO,2CrO_3$ the characteristic yellow precipitate will be produced. (See TABLE XXIII., Observation *c.*)

‖ *e.* This will of course produce a yellow precipitate. The detection of cadmium, when copper is present at the same time, may be effected by a more expeditious method, which consists in adding an excess of KCy to the ammoniacal liquor, the blue colour of the copper is thereby entirely destroyed, and a double cyanide of cadmium and copper formed. On passing a stream of HS through this liquor, which should be warm, the cadmium alone is precipitated, provided enough KCy has been added, whilst the copper remains in solution, from which it may subsequently be precipitated also in the state of CuS (black) by adding an excess of HCl to the liquor filtered from the yellow precipitate of CdS. To remove all doubts, metallic copper may be at once extracted from the black sulphuret by mixing it with NaO,CO_2, or, better still, with equal parts of NaO,CO_2+KCy and heating before the blow-pipe on a charcoal support (see TABLE I.—B., Observation *n*)—Cu—Cd—Ag—Pb and Bi may, therefore, be readily separated by this method, which may be thus recapitulated:—

1°. Add an excess of HCl to the liquor under examination. This precipitates the greatest part of Pb, and the whole of Ag, which, if it has been recognized before, may now be identified as described in TABLE XIV., Cols. 4 to 7, and Observations thereon.

2°. To the liquor filtered from the Pb and Ag add KO,CO_2 as long as a precipitate is formed, and then add further a pretty large excess of KCy, the precipitate produced thereby consists of PbO,CO_2 (from the lead which HCl failed in precipitating) and BiO,CO_2, filter.

3°. Treat the liquor filtered from 2°, and which contains the Cd and Cu in the state of double cyanide, as above said. (See also TABLE XXIV., Observation *a.*, par. 2.)
The presence of Bi may be recognized in the precipitate of BiO,CO_2 by mixing a portion of the said precipitate with NaO,CO_2, and heating before the blow-pipe on a charcoal support, whereupon a brittle metallic bead, accompanied by an incrustation, will be produced. For confirmation, this bead may be dissolved in NO_5, and the solution submitted to the tests which are characteristic for that metal. See the Dictionary.

TABLE XVIII.

Systematic Analysis of MIXED COMPOUNDS which are SOLUBLE IN WATER.

Treatment of the Acidified Solution not precipitated by HS, or of the Liquors filtered from the Precipitates produced by HS, alluded to in Cols. 1, 2, 3, TABLE XV., and of the Precipitates produced by HCl in the Liquors with an Alkaline Reaction, alluded to in Col. 21, TABLE XIV.

Ascertain first, whether the liquid contains any fixed residue by evaporating a few drops on a strip of platinum foil, and if a fixed residue be left, proceed as follows:—
Take a small portion of the liquor under examination, add an excess of sal-ammoniac to it (Observations *a*, *b*), and likewise enough NH_3 to render it decidedly alkaline to test-papers (Observation *c*), and, whether or not a precipitate is thereby produced, add NH_4S. If this produces—

NO PRECIPITATE,

Proof that Fe—Ni—Co—Mn—Cr—Zn—Al—are absent. Go to TABLE XIX.

A Black, | Grey, | or otherwise Coloured Precipitate.

Proof of the presence of Fe—Co—Ni—Cr—but, possibly, also Zn—Al—and, if the original solution was acid, acid phosphates, oxalates, borates, arseniates of earths, or either of them, may be present.
If the precipitate was BLACK or BLACKISH, the presence of Fe—Co—Ni is certain. (Observations *d*, *e*, *f*.)
Treat the rest of the liquor exactly as the small portion operated upon; that is to say, add sal-ammoniac (if necessary), then NH_3, and then NH_4S, as long as a precipitate is produced; separate the precipitate by filtering.

White Precipitate.

Presence of Zn—Al.—But Fe—Co—Ni may also exist in the liquor in very small quantities, though in that case, the precipitate, instead of being pure white, has a more or less greyish tinge; if the solution was acid it may contain also acid phosphates, oxalates, borates, and arseniates of earths, or either of them. It may contain also the more rare substances Gl—Th—Y- Ce—Zr—Ti—Ta, but these will be taken account of in the Supplementary Tables.

Treat the rest of the liquor as the small portion operated upon, that is to say, add sal-ammoniac (if necessary), then NH_3, and then NH_4S, as long as a precipitate is produced—separate the precipitate by filtering, and examine at once whether the filtrate contains anything, as at Col. 1; as to the precipitate, wash it thoroughly with water, dissolve it in HCl, boil until all odour of HS has completely disappeared, and filter, to separate the sulphur.

(If a very small black residue, insoluble in HCl, is left, it is due to the presence of traces of Co or Ni; add, then, NO_5, and boil until all is dissolved, except the sulphur, which may be separated by filtering.)

* Pour an excess of cold caustic, KO, upon this precipitate; if it dissolves completely, Al_2O_3, or its phosphate alone, or mixed with Cr_2O_3.

The FILTRATE.

Examine whether the filtrate contains anything by evaporating a few drops on platinum foil, and if a fixed residue is left, treat the filtrate as directed in TABLE XIX.

The PRECIPITATE.

Wash the precipitate thoroughly with water containing a little NH_4S, and then pour upon it, *whilst in the filter*, a certain quantity of HCl, diluted with five or six times its bulk of water.

Does NOT DISSOLVE Completely, or at all.

But a residue is left, which is

Black.

Presence of Co—Ni.—Fuse at once a portion of this residue with borax, on the hook of a platinum wire before blow-pipe; if a blue bead is produced, it indicates, of course, the presence of Co.—But as Ni may also be present at the same time, wash the whole residue down into the HCl liquor which was filtered from that residue, add NO_5, and boil, in order to dissolve it all.

DISSOLVES Completely.

Presence of Fe—Cr—Mn—possibly acid phosphates—oxalates—borates and arseniates of earths—Zn—Al—and perhaps, also, small quantities of Co—Ni—for these two sulphurets are not quite insoluble in dilute HCl. To the solution of the precipitate in HCl add NO_5, and boil, in order to convert any FeO which may be present into Fe_2O_3.

Take a small portion of this acid solution, add thereto a few drops of CaCl, and then as much NH_3 as is necessary *nearly*, but not quite, to neutralize it, and whether or not a precipitate is formed, add excess of $\overline{A}$,HO.

NO Precipitate, or if one is produced, it is completely redissolved by the excess of $\overline{A}$,HO employed.

Filter, if necessary, and to the liquor add as much KO as is necessary to neutralize the $\overline{A}$,HO, and then a drop or two of Fe_2Cl_3. If this produces a yellowish white precipitate, phosphates are present. The liquor may also contain borates and arseniates, which will be detected below.

A Precipitate insoluble in excess of $\overline{A}$,HO. (Observation *g*.)

Presence of oxalates of earths.—If the quantity is small, twelve hours may be required for the precipitate to appear. Filter, and treat the filtrate as if the precipitate had dissolved.

Whether or not a precipitate was produced when testing for phosphates or oxalates, as just said, add now an excess (large) of KO, to the rest of the solution in NO_5 of the precipitate produced by NH_4S, boil (Observation *h*), dilute with water, and filter.

The FILTRATE.

Divide into Four Portions.

First. To the clear strongly alkaline filtrate add NH_4S.

White.

Zn. (Observat. *i*.) Confirm by heating a small portion of the precipitate, moistened with CoO,NO_5, before the blow-pipe.

Emerald Green.

Zn.

Second. Acidify the strongly alkaline filtrate with HCl, add excess of NH_3, and shake. (Ob. *i*.)

White.

Al. Confirm by heating before the blow-pipe a portion of the precipitate moistened with CoO,NO_5.

Blue.

Al.

Third. Acidify the strongly alkaline filtrate with NO_5, add an excess of AgO,NO_5, filter, if necessary, add a drop or two more of AgO,NO_5 to the filtrate, and neutralize *exactly* with NH_3.

Light Brown.

AsO_5.

Fourth. Evaporate the filtrate, previously acidified, nearly to dryness, pour concentrated SO_3,HO upon the residue, add alcohol or naptha, and inflame the mixture.

Yellowish Green Flame.

BO_3. (Observation *j*.)

BO_3.

The PRECIPITATE.

Wash the precipitate thoroughly with water. If the original solution was colourless, it is probable that NO Cr or Co are present. (Observation *k*.)

Mix a portion of the precipitate with NaO,CO_2 + a little KO,NO_5, and heat strongly before the blow-pipe on a strip of platinum.

Turquoy Blue.

Mn. Confirm by boiling a portion of the precipitate with NO_5 and red lead.

Rich Purple Colour.

Mn.

Fuse another small portion of the precipitate with borax before the blow-pipe.

Blue Bead.

Co. (See TABLE V., Observation *n*.)

Co.

Triturate a small portion of the precipitate with NaO,CO_2 + three parts of KO,NO_5, fuse the mass thoroughly in a small porcelain crucible until all intumescence has ceased. Boil the fused mass with HO, separate the insoluble residue by filtering, add to the filtrate some $\overline{A}$,HO, to acid reaction, and test it with $PbO,\overline{A}$.

Yellow.

(Observation *k*.) Confirm by fusing a portion of this precipitate with microcosmic salt, upon hook of platinum before the blow-pipe.

After cooling,

Emerald Green Bead.

Cr. (See TABLE V., Observat. *t*.)

Take a fresh portion of the compound, well-pulverized, or, if a liquid, evaporate to dryness, and transfer it to a platinum crucible. Pour concentrated SO_3 upon the mass, cover the crucible with a plate of glass coated with wax, on which lines or figures have been drawn, as directed in the tests for HFl.

Corrosion.

HFl.

Dissolve about half of what is left of the precipitate in NO_5 and divide into two portions.

First Portion. Neutralize as nearly as possible, *but not quite*, with NH_3, filter, if necessary, and to the clear filtrate add a drop of Fe_2Cl_3 + *excess of KO,A*. (Observation *n*, TABLE IX.)

Yellowish White.

PhO_5. (Observation *l*.)

Second Portion. Evaporate to a very small bulk, transfer to a glass tube of sufficient length, or to a small flask, add some finely levigated MnO_2 and some concentrated SO_3, cork the tube with a sound cork provided with a disengagement tube, and apply heat. When the air of the tube has been expelled, and gases *manifestly begin to be evolved*, collect them into another test-tube, placed in a small water-trough, as described in the test for $\overline{O}$,HO, in Dictionary. Remove the tube containing the gas collected, carefully closing its mouth with the thumb, introduce rapidly a small bit of caustic KO, replacing suddenly the thumb on the tube's mouth, shake well, and ignite the gas left.

Burns with a Blue Flame.

Oxalates of earths. (Observation *m*.)

$\overline{O}$,HO.

Dissolve the rest of the precipitate in a small quantity of HCl, and divide into two portions.

First portion. Test with K_2Cfy. (Observ. *n*.)

Prussian Blue.

Fe. To ascertain whether Fe existed in the compound as FeO or Fe_2O_3, acidify slightly the original solution with HCl, and divide into two portions.

First Portion. Add K_2Cfy.	Second Portion. Add (2Cfy)3K.
Blue.	Blue.
Fe_2O_3.	FeO.

Second Portion. Add more HCl, and an excess of KCy, until it has an alkaline reaction, boil, and add SO_3,HO to the filtrate.

Light Yellowish Green.

Ni.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

OBSERVATIONS ON TABLE XVIII.

a. The addition of sal-ammoniac prescribed is for the purpose of preventing any magnesia which may be present, from being precipitated by the NH_3 and NH_4S employed. If, however, the quantity of HCl which has been added before has been large enough to form a sufficient quantity of sal-ammoniac, with the ammonia with which the liquor is now to be supersaturated, it is clear that it will be useless to make any further addition of sal-ammoniac.

b. If the addition of ammonia to the solution to which NH_4Cl has already been added, and before pouring any NH_4S, if, I say, the addition of ammonia produces a precipitate, the presence of alumina, of chromium, and of iron, of cobalt, of per-phosphates, oxalates, arseniates, borates, and fluorides of earths, or either of them, is certain. If that precipitate is white, alumina is present; but if the original solution was acid, then per-phosphates, or arseniates, or fluorides of earths, or either of them, are present besides. If a sufficient quantity of sal-ammoniac has not been employed, borates and oxalates of earths, even oxalates of magnesia, will also be precipitated by NH_3.

c. If, after having supersaturated the solution with ammonia, *and before adding the hydro-sulphuret of ammonia*, the supernatant liquor is blue, or if a small portion of the mass being filtered, the filtrate is blue, it is due to the presence of nickel. Of course, this, if done at all, must be done before pouring the NH_4S, since this latter reagent produces, with nickel, a black precipitate of NiS. And further, if, after having added NH_4S, the filtrate from the black or grey precipitate thereby produced is black or brown, it is due also to the presence of nickel, the sulphuret of this metal not being quite insoluble in NH_4S. It may be due also to the presence of copper, since sulphuret of copper is not quite insoluble either in NH_4S, especially if it contain an excess of NH_3, though much more so than NiS.

Group 8 *to* 10.

d. Although the precipitate produced by NH_4S in solutions of Fe—Ni—Co is black; and of Cr, greenish; of Mn, flesh-coloured; of Zn and Al, white; yet all these may possibly be present in the coloured precipitate under consideration, because, if only in very small proportion, their respective colours will be masked or altered, and thus Cr and Mn, Al and Zn, might be concealed. The presence of Fe—Ni—Co, however, cannot be overlooked, because a small proportion of these metals is sufficient to impart a grey or black colour to the white precipitate produced by Zn and Al. A mere trace of Fe is sufficient to give a greyish hue to ZnS. *

e. If the original solution was colourless, it is probable that no Cr, and also no Co, are present, but the solution may have a colour and yet contain no Cr or Co.

f. If Fe—Ni—Co—Mn—Cr—Zn—Al, or any of them, are present, it will be useless to look for CO_2—BO_3—AsO_3—AsO_5—PhO_5—SiO_3, as combined with them, since the salts resulting from the combinations of these acids and metals are insoluble in water. It is only if the original liquor was acid that such combinations may exist in the solution under examination.

g. If $\overline{A}$,HO fails to redissolve the precipitate which began to appear when nearly neutralizing the acid liquor with NH_3, an oxalate of earth is probably present, because such oxalates are not soluble in $\overline{A}$,HO.

h. There should be a pretty large excess of KO employed, wherefore it is advisable to dissolve at once a suitable quantity of solid caustic potash (of course, free from alumina) in a little water, to add it to the acid solution, and to boil the whole. The operator must be sure that a sufficient quantity of caustic potash has been used to redissolve the alumina or zinc which may be present.—Do not omit to boil the whole for some time, because Cr_2O_3 is readily soluble in cold KO. In some cases, however, it happens that Cr_2O_3 cannot even be wholly precipitated from a KO solution by any amount of boiling, but in that case the liquor generally has a greenish colour † Caustic soda may be used instead of caustic potash, and is generally to be preferred on account of its being free from alumina.

Group 3 *to* 6.

i. (Col. 3.) It frequently happens with solutions which contain no zinc, but which contain alumina, that the operator, in treating the strongly alkaline filtrate by NH_4S, produces a white precipitate, which may at first be mistaken for ZnS, but which is really nothing else than Al_2O_3; or that although both Zn and Al are present, the addition either of NH_4S, or of NH_3, will produce no precipitate. This is owing to his not having used enough KO in the first instance, or to his not having boiled the mixture long enough. If the liquor was very acid, the excess of acid should be evaporated by heat, before adding the potash. From a colourless, clear, and strongly alkaline solution, the precipitate produced by NH_4S can hardly be anything else than ZnS. ‡

j. (Col. 6.) The best way of operating for the detection of BO_3 consists in heating the little capsule containing the precipitate, the sulphuric acid, and the alcohol, previous to igniting it, extinguishing the flame by blowing upon it, and lighting it again, when the edges of the flame will then be tinged with the characteristic yellowish-green colour. (See also Turner's test, in Dictionary.)

Group 7 *to* 15.

k. (Col. 9.) If Cr is present, the filtrate obtained after boiling the fused mass with water will have a yellow tinge, owing to the presence of KO,CrO_3. If Mn was present at the same time, the fused mass will have a turquoy-blue colour. The residue, insoluble in boiling water, contains the Co—Mn—Fe—Ni, which may have existed in the compound, and may, therefore, be tested accordingly.

l. (Col. 11.) For the detection of the earths in per-phosphates, add to the rest of the portion just tested, an excess of Fe_2Cl_3, and an excess of $KO,\overline{A}$, boil for a few minutes and filter; the filtrate contains the earths that were combined with the phosphoric acid in the solution, which originally must have been acid, since the neutral phosphates and of earths are insoluble in water, as we have already had repeated occasions to remark. § (See also Table XI, observ. *m.*)

m. (Col. 12.) Before using MnO_2 for the detection of oxalates, wash it with dilute NO_5, in order to remove the carbonates of earths, which frequently contaminate it, and which of course would interfere with the test.

Group 13 *to* 14.

n. (Col. 13, 14.) If the solution contained manganese, cobalt, or nickel, the addition of K_2Cfy will produce with the first, a greyish-green precipitate; with the second, a green precipitate, becoming grey; and with nickel, a greenish-white precipitate. (2Cfy)3K will produce, with manganese and cobalt, a brown precipitate; and with nickel, a greenish-yellow precipitate. Oxyde of chromium is not affected by these reagents.

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* *d.* CoS and NiS are sparingly soluble, but not quite insoluble, in dilute HCl, nor even in $\overline{A}$,HO—ZnS is insoluble in the latter acid, in which MnS is soluble.

If Fe exists in the liquor in the state of a ferrocyanide it will not be precipitated by NH_4S, and in such case it is necessary to have recourse to a special method, as follows: evaporate a portion of the liquor filtered from the precipitates produced by NH_4S to dryness, ignite the residue, which, in that case, will turn brown by charring, treat the ignited mass with water; filter, and examine the filtrate for iron by K_2Cfy, which will produce a blue precipitate.

† *h.* In such cases, the best course, perhaps, to adopt consists in taking the precipitate produced by NH_4S while still moist, and boiling it for some time with a concentrated solution of caustic KO, to which a certain quantity of pure oxyde of lead is added. The liquor, which, if chromium was present, contains it now in solution, in the state of chromate of lead, and which solution has then a yellow colour, should be supersaturated with $\overline{A}$,HO, which precipitates the whole of the yellow chromate of lead. This precipitate is separated by filtering, and the filtrate, which is of course acid, being first neutralized with NH_3, is then precipitated by NH_4S, washed thoroughly, and dissolved in aqua regia; this aqua regia solution may then be boiled with a good excess of KO; if this produces a precipitate, it should be separated by filtering, taking care to dilute the liquor which holds it with water—for, otherwise, it would burst the paper filter—and both the precipitate and the filtrate may then be treated as directed in Cols. 3 to 15.

‡ *i.* On the other hand, the presence of organic matters—even that resulting from portions of the filter which may have dissolved in the liquor—interfere with, or may altogether prevent the precipitation of alumina. Therefore, when alumina fails in being detected, and, of course, more especially still when the operator has reason to suspect its presence, it is always advisable to boil the liquor with an excess of HCl, adding a little KO,ClO_5, from time to time, in order to destroy the organic matter which may be present, as described in Table I.—D., Col. 2; after which the addition of NH_3 will precipitate the alumina as usual, in the shape of flakes, if that base be present.

But, as phosphate of alumina behaves with reagents like pure alumina, the operator must examine whether the precipitate thus obtained contains phosphoric acid, and the best method, perhaps, is the following: separate the flocculent precipitate of alumina in question by filtering, and mix it with a little NaO,CO_2 and a little of the pure silica obtained from the analysis of silicious minerals; fuse the mixture in a little platinum capsule, dissolve the fused mass in boiling water, filter to separate the insoluble silicate of alumina produced, neutralize the filtered liquors exactly with dilute NO_5, dilute a portion of the liquor, and add a few drops of AgO,NO_5; if phosphoric acid is present, a yellow precipitate of phosphate of silver is produced. The neutralization of the liquor by NO_5 is not absolutely necessary, but is only advisable, for, otherwise, a white precipitate is always produced, which, mixing with the yellow phosphate, renders its colour less intense, and, consequently, less readily observable. For confirmation, boil the other portion

of the liquor with an excess of sal-ammoniac, in order to decompose the silicate of soda produced; filter to separate the silica, and to the filtrate, which contains the phosphoric acid in the state of phosphate of soda, add sulphate of magnesia, and shake the whole vigorously; if phosphoric acid is really present, a characteristic white crystalline precipitate of ammonia-phosphate of magnesia will appear.

Phosphoric acid may always be separated from all the earths by a special process, which consists in dissolving the compound in NO_5, and adding metallic tin to the liquor; the tin becomes rapidly oxydized, and an insoluble phosphate of tin is formed, at the expense of the phosphoric acid of the earthy phosphates. The whole liquor is evaporated to dryness; the dry mass is then treated by water, to separate the insoluble phosphate of tin; and the filtrate, which contains all the earths, may then be examined as directed in the Tables. The phosphate of tin, after washing, may be dissolved in HCl, and, after diluting the solution with water, the tin may be precipitated by HS, and the liquor filtered from the sulphuret of tin being boiled until all the HS has evaporated, may then be tested in the usual way for phosphoric acid.

§ *l.* The phosphates of all the earths are insoluble in KO, except phosphate of alumina, which dissolves in KO as if it were pure alumina; the means of detecting phosphate of alumina have just been described, Observ. *i.* A very good process for the detection of phosphoric acid in mixtures of phosphates with other salts of lime, is the following: Dissolve the compound in HCl, filter, add oxalate of ammonia, boil and add an excess of acetate of ammonia, filter to separate the oxalate of lime, add a little tartaric acid to the liquid, in order to keep the iron which may be present in solution, and add ammoniacal solution of magnesia to the filtrate; a white precipitate is produced which is ammonia-phosphate of magnesia. The peculiarity of the process consists in the acetate of ammonia, which being thus added to the oxalate of lime kept in solution by the HCl, produces NH_4Cl, and liberates acetic acid, in which oxalate of lime is insolube, and may be separated by filtering. For the preparation of the ammoniacal solution of sulphate of magnesia see the Dictionary of Reagents. (See also TABLE XI., Observation *m.*, TABLE XXI., Observation *h*, and TABLE XXII.—A., Observation *n.*)

Systematic Analysis of MIXED COMPOUNDS which are SOLUBLE IN WATER.

Treatment of the Acidified Solution not Precipitated by HS, nor by NH_4S, and of the Liquors which were filtered from the Sulphurets produced by these reagents.

The Liquor may contain BaO—StO—CaO—MgO—KO—NaO—NH_3. (Observation *a*.)

Examine whether the liquor contains anything, that is, any fixed base, by heating a few drops of it on a strip of platinum foil, and heating to redness. If nothing remains on the foil, the liquor may be thrown away, as it is a proof that it contains no fixed bases; if otherwise, proceed as follows:—

Supersaturate the liquor filtered from the precipitates which have been produced by HS, or NH_4S, with HCl, and boil until all odour of HS has completely vanished. (Observation *b*.) Or if the portions of the original solution which have been tested by HS, or NH_4S, yielded no precipitates by these reagents, add HCl to the whole of the original solution affected to the detection of bases, and filter if necessary. To this acid liquor add a sufficient quantity of NH_4Cl, (Observation *c*), then some NH_3 (Observation *d*), then a sufficient quantity of NH_4O,CO_2, and heat the whole gently for some time, *but not to boiling*. (Observation *e*.)

1	2	3	4	5	6	7
NO PRECIPITATE.	A PRECIPITATE is produced which is soluble in ACIDS, with Effervescence.					
Absence of Ba—St—Ca— Possible presence of Mg—Na—K.	Presence of Ba—St—Ca. Treat the whole of the solution with NH_4O,CO_2, and filter, and wash carefully with hot water.					
Examine whether any fixed residue is left by evaporating a few drops of the liquor on platinum foil, and heat to redness. If a residue be left, examine the liquor, as directed, Table XX.	THE FILTRATE. Examine whether any fixed residue is left by evaporating a few drops of the filtrate on platinum foil, and heat to redness. If a residue be left, test the filtrate as directed, Table XX.	THE PRECIPITATE. Dissolve the precipitate in $\overline{A},HO$ (this solution is, of course, accompanied by an effervescence,) dilute a portion thereof with water, and test with $KO,2CrO_3$. (See Table VI., Observation *f*, and Table X., Observation *c*.)				
		Yellow.		**No Precipitate.**		
		Presence of Ba. But St and Ca may be there also. Treat the rest of the solution by $KO,2CrO_3$, as long as a yellow precipitate is produced, and filter.		Ascertain whether any fixed residue is left by evaporating a few drops on a platinum foil, and heating to redness, as described, Col. 1, and if a fixed residue be left, evaporate the rest of the solution to dryness, redissolve the residue in water, and divide into two portions.		
		The Yellow Precipitate.	**The Filtrate**	1st Portion. Add aqueous solution of CaO,SO_3 to a portion thereof, shake violently, and leave the whole at rest for some time.		2nd Portion. Add thereto some KO,SO_3, apply a gentle heat, leave at rest for some time (if a precipitate is produced, it is StO,SO_3, which is to be separated by filtering), and to the clear liquor or filtrate add an excess of NH_3, and then some $\overline{O},HO$.
		Presence of Ba. (Observation *f*.) Confirm by testing a portion of the original solution with $HFl,SiFl_2$.	may contain St—Ca. Add as much NH_4O,CO_2 as is necessary to precipitate the whole of these earths (after having, of course, ascertained that a fixed residue is present in the filtrate), wash the precipitate with water until the yellow colour, due to the excess of $KO,2CrO_3$ employed, has vanished, dissolve the white precipitate left in HCl, divide into two portions and treat as directed, Col. 5 to 7.	**White Precipitate.** Presence of St. Confirm by evaporating to dryness, add to the dry residue a few drops of HCl and some alcohol, ignite, and stir the mixture at the same time.	**No Precipitate.** Supersaturate the rest of the liquor with NH_3, and then add some $\overline{O},HO$.	**White.** Ca.
		White Crystalline. In dilute solutions this precipitate requires some time for its production. (See Table VI., Observation *e*.)		**Carmine Red Flame.** (Observation *g*.) St.	**White.** Ca. The precipitate is readily soluble in HCl and in NO_5. Ca.	**White.** Ca. Ca.
		Ba.				

OBSERVATIONS ON TABLE XIX.

a. If (the original liquor being acid) phosphates of earths have been detected, the operator must decompose the solution by adding to it, if necessary, as much HCl as will impart to it an acid reaction, then *an excess* of acetate of potash (see TABLE IX., Observation *n*), and then as much per-chloride of iron as is necessary to render the liquor red. If it becomes red before adding the per-chloride of iron, it is a proof that the liquor already contains a sufficient amount of iron. The whole is then boiled for a few minutes, in order to precipitate all the phosphoric acid combined with the iron employed; the liquor is then filtered; and the earths with which the phosphoric acid was combined will now be found in the filtrate in the state of chlorides.

If oxalates of earths have been found, the precipitate caused by NH_3 or by KO should be ignited, which will convert the earthy oxalate into an earthy carbonate, which, being now dissolved by an acid, may be tested for the earths.

b. Whilst boiling the filtrate with a slight excess of HCl, a milkiness is produced, which is only due to a separation of the S, resulting from the decomposition of the NH_4S employed previously; this S must be separated by filtering.

c. The addition of NH_4Cl to the liquid in which the hydro-sulphuret of ammonia (NH_4S) has been decomposed by HCl, is not necessary, because in doing so enough sal-ammoniac will have been formed to prevent MgO from being precipitated by the NH_4O, CO_2, which is now to be used.

d. If NH_3 produces a precipitate in this solution, it is probably due to the presence of phosphates, oxalates, &c. of earths, which, however, will have been detected in the preceding Table, in which case the original liquor must have been acid. If so, the liquid under present consideration must be treated as directed in Observation *a*. If, however, the earth combined with phosphoric acid is alumina, it is necessary to adopt a different process; that is to say, the precipitate, if one have been formed, is re-dissolved in HCl, an excess of tartaric acid is then added, and then ammonia, which fails now in producing a precipitate, on account of the presence of the tartaric acid (see Observation *p*, TABLE IX.) If now sulphate of magnesia be added and the mass shaken, the phosphoric acid will be precipitated as basic phosphate of magnesia and ammonia, $\overline{(2MgO)\ NH_4O,\ PhO_5}$ which, after allowing the whole to remain at rest for about ten or twelve hours, may be filtered, and the filtrate then contains the alumina, which was combined with the phosphoric acid. As the filtrate, however, contains, at the same time, some magnesia, from the excess of sulphate of magnesia employed, regard must, of course, be had to this circumstance. *

e. The liquor must not be boiled, for fear of precipitating some MgO.

Group 3, 4.

f. (Col. 3.) The yellow precipitate of BaO,CrO_3 is insoluble in $\overline{A},HO$, but is readily soluble in NO_5 and HCl.

Group 5 *to* 7

g. (Col. 5.) The carmine red colour imparted to the flame of alcohol is more intensely developed by stirring the mixture whilst burning, especially towards the end, that is, when it is nearly all burnt out; but if a salt of soda is present, it imparts to it a crimson colour, and if in sufficient quantity completely substitutes its own yellow colour to it. Baryta salts likewise modify this carmine colour; this is more especially the case with chloride of barium, which may altogether prevent its appearance. Lime burns, when treated in that way with alcohol, with a carmine colour which much resembles that of strontia; it is, therefore, only when none of these substances are present, that the carmine colour of the flame can be considered a characteristic test for strontia. If the whole of the baryta have been removed by means of $KO,2CrO_3$, the present solution may be tested with KO,CrO_3, and boiling, which, if strontia is present, will produce a copious yellow precipitate.

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* *d.* The other methods indicated in TABLE XVIII., Observation *i*, paragraph 3, may also be followed.

Systematic Analysis of MIXED COMPOUNDS which are SOLUBLE in WATER.

Treatment of the Solution which was not Precipitated by HS, nor by NH_4S, nor by NH_4O,CO_2, or of the Liquors which were filtered from the Precipitates produced by these reagents.

The Liquor may contain Mg—K—Na. (All the Salts of Na and K are Soluble in Water.)

Evaporate to dryness a portion of the liquor filtered from the precipitates produced by NH_4O,CO_2 (TABLE XIX); or of the original liquor in which this reagent failed to produce a precipitate, ignite the dry mass until white fumes are no longer evolved, in order to expel all the ammoniacal salts (Observation *a*). dissolve the ignited mass in the smallest possible quantity of water, or if a white powder is left which refuses to dissolve in the water, add a few drops of HCl, evaporate to dryness, redissolve in water, and divide the liquor into two portions.

EXAMINATION of the Compound for AMMONIA.

Take some of the original solution, to which, of course, no ammonia has been added, pour into it a concentrated solution of KO, and apply heat, if necessary, to develope the reaction. *

Pungent odour of NH_3.

Hold a glass rod moistened with non-fuming HCl, or with strong acetic acid, over the mass

White Fumes.

The vapours also restore the blue colour of reddened litmus paper, previously moistened with water.

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* When the quantity of NH_3 evolved by treatment with solution of KO is very small, its presence in the compound is not satisfactorily proved by this test, since caustic potash itself always evolves a little NH_3 when heated; it is therefore necessary to triturate the compound with caustic, lime, and a little water, instead of solution of potash, and if NH_3 is then evolved, it is evidence of its presence in the compound under examination.

NH_3.

4

1st PORTION.

Add $\overline{(2NaO)HO, PHO_5,}$ and shake vigorously. (Observation *b*.)

White Precipitate.

Mg.

If the sides of the glass tube be rubbed with a glass rod, white marks will appear where the glass rod will have touched the tube. (See also TABLE VI., Observations *m*, *n*.)

Confirm by heating a portion of the precipitate upon charcoal before the blow-pipe, moisten the mass which has been thus heated with a drop of CoO,NO_5, and heat it again strongly before the blow-pipe, if it becomes of a

Pale Pink colour,

Mg.

(Observation *c*.)

Mg.

1

2ND PORTION.

Add some alcohol, heat, and inflame.

Purple Flame.

KO.

Confirm by adding an excess of $\overline{T}$,2HO, and shake violently.

White Precipitate

(See TABLE VI., Observations *r*, *s*, *t*.)

The addition of alcohol promotes the formation of this precipitate.

To another portion add solution of $PtCl_2$, and a little alcohol.

Yellow Precipitate.

(Observations *d*, *e*.)

K.

2

Yellow Flame.

Certain presence of NaO.

But as KO may be present at the same time, since the yellow flame of NaO overcomes the purple flame of KO, the liquid should be tested for the latter base by $\overline{T}$,2HO, and by $PtCl_2$, as described in Col. 2.

Na.

3

OBSERVATIONS ON TABLE XX.

a. If iodide of potassium be present in the solution which contains sal-ammoniac, violet fumes of iodine may be observed to be evolved whilst evaporating to dryness and igniting.

b. (Col. 1.) Remember that baryta, strontia, and lime are, like magnesia, precipitated by $\overline{NaO, NH_4O, HO, PhO_5}$, and, therefore, the absence of those earths must be ascertained before testing with phosphate of soda. Wherefore the liquor, before being evaporated to dryness and ignited, as just described, should be tested, one portion with KO,SO_3, and another with $NH_4O,\overline{O}$; neither of which tests should produce any precipitate. If, on the contrary, a precipitate is produced, it is a proof that all the Ba—St, or Ca, have not been removed; and the liquor should be again treated with a fresh portion of NH_4O, CO_2, filtered, and the filtrate may be then tested as directed in this Table.

In dilute solutions, the presence of magnesia can be readily detected by pouring NH_4O, CO_2 + $\overline{NaO, NH_4O, HO, PhO_5}$, into the magnesian solution. The portion to be tested is to be spread on a piece of glass, and by writing upon it with a glass-rod, the writing will appear white.

c. (Col. 1.) The pale pink colour is characteristic of the presence of magnesia, but it is very weak, and cannot be well perceived, *except after the mass has become perfectly cold.*

d. (Col. 2.) Before applying $PtCl_2$ as a test for potash, make sure that no ammonia or ammoniacal salts are present, since otherwise a yellow crystalline precipitate (NH_4Cl + $PtCl_2$) would also be produced.

e. If the solution contains iodide of potassium, the addition of $PtCl_2$, instead of producing a granular yellow precipitate, will yield a dark purple colour. *

f. (Col. 4.) As, however, solution of caustic potash itself evolves NH_3 when heated, it is well, in order to establish beyond doubt the presence of NH_3 in the compound, to triturate it with caustic lime and a little water, instead of the solution of potash, as mentioned in the TABLE.

TABLE XXI.

Systematic Analysis of MIXED COMPOUNDS which are SOLUBLE IN WATER, and which may contain INORGANIC ACIDS ONLY (whether Organic Acids are present or not will have been detected in the Preliminary Examination, TABLE I.—C., and I.—D.)

Through the liquor under examination, and slightly acidified with NO_5 (Observ *a, d,)*, pass a stream of HS to supersaturation; filter, if necessary. Boil the filtrate (or the liquor not precipitated by HS) until all odour of HS has disappeared, and add thereto an excess of NH_3. (Observ. *b.*) Filter again, if necessary, and to the filtrate (or to the liquor in which this reagent failed to produce a precipitate) add NH_4S, as long as a precipitate is produced (Observ. *d*), and filter, if need be. Concentrate by heat, if necessary (Observation *c*), *neutralize it exactly* with NO_5 and by NH_3, if too much acid has been employed, and *vice versâ*, as the case may be, and divide it into two portions. (It is always easy to neutralize exactly by using very dilute NO_5 or NH_3. (Observations *e, f.*)

FIRST PORTION.
Add solution of BaO,NO_5; heat gently.

NO PRECIPITATE.

Test with AgO,NO_5, as directed for the examination of the second portion.

PRECIPITATE.

Presence of BO_3 (Observation *j*)—SO_3—IO_5—(AsO_3—AsO_5, Observation *f*)—PhO_5—HFl—SiO_3—CrO_3.

Add BaCl to the rest of the solution as long as a precipitate is produced; boil, filter, and wash. (Observation *g.*)

Dry a portion of the precipitate, mix it with pulverized $KO,2SO_3$ (about twice its bulk), and apply the heat of a spirit-lamp.

Violet Fumes.

IO_5.

Digest the whole of the precipitate in HCl.

Does NOT dissolve completely, or at all.

(Filter, and treat the filtrate as if the precipitate had dissolved.) SO_3. Test a portion of the insoluble residue with NaO,CO_2 on a charcoal support, remove the fused mass (or the charcoal on which the fusion took place), put it on a clean piece of silver and moisten with dilute HCl.

Odour of HS.

Brown Stain.

SO_3.

See TABLE VII., Observation *s.*

SO_3.

Dissolves Completely. (Obs. *g.*)

Add NH_3 to the acid liquor until it acquires a *very slight* alkaline reaction. Add CaCl, and boil. (Observation *g, h.)*

White Precipitate.

SO_2BO_3—PhO_5—PhO_3—$\overline{O}$,HO—HFl.—Digest in $\overline{A}$,HO.

Does NOT Dissolve.

(Filter, and treat the filtrate as if it had dissolved.) $\overline{O}$,HO—HFl. Treat this insoluble precipitate with HCl.

Does NOT Dissolve.

HFl. (Filter, and treat the filtrate as if the precipitate had dissolved.) Confirm by treating it with SO_3 in platinum crucible, and a piece of waxed glass bearing tracings as described in the test for HFl (which see).

Corrosion.

See TABLE VII., Observation *w.*

HFl.

Dissolves.

$\overline{O}$,HO. Add excess of NH_3 to this solution.

White.

Collect and dry the precipitate, treat it in a test-tube with MnO_2 $+SO_3HO$ (or else take a portion of the original compound) and, having applied heat, inflame the gas evolved.

Blue Flame.

(See tests for $\overline{O}$,HO, and TABLE VII., Observat. *x.)*

$\overline{O}$,HO.

Dissolves. (Observation *i.*)

BO_3—PhO_5—PhO_3, add excess of NH_3.

O.

Certain absence of PhO_5. Possible presence of BO_3. Treat a small portion of the original compound with SO_3HO+ alcohol, and inflame.

Yellowish Green Flame.

BO_3. Observation *j.*, and TABLE VII., Observation *a'*.

BO_3.

Precipitate. (Observation *j.*)

Mix a small portion of the precipitate with SO_3HO + alcohol, and inflame.

Yellowish Green Flame.

BO_3. See TABLE VII., Observation *a'*.

BO_3.

Redissolve the precipitate in $\overline{A}$,HO, and divide into two portions.

First Portion. To a little of that portion add enough KO *nearly* to neutralize the excess of $\overline{A}$, add an excess of $KO,\overline{A},HO$ and then as much Fe_2Cl_3 as will render the liquor red. Boil for a few minutes (Observ. *k*), filter, wash the precipitate with boiling water, redissolve it in HCl, add excess of $\overline{T},2HO$, and then an excess of NH_3, and to this transparent yellow liquid add MgO,SO_3, and boil.

White.

PhO_5.

Second Portion. To a little of that portion, nearly neutralized, add AgO,NO_5.

Brown.

By boiling,

Black.

PhO_3.

Add to the original solution of that portion some SO_2, and heat gently.

Milkiness from Sulphur.

PhO_3. (Observ. *k.*)

BO_3.

PhO_5.

$HCyS_2$.

BrO_5.

$HCyS_2$.

IO_5.

SECOND PORTION.
To the second portion, exactly neutralized, as just said, add AgO,NO_5.

NO PRECIPITATE.

Go to Cols. 21, 22. Observ. *l.*

PRECIPITATE. (Observations *m* to *s.*)

PhO_5—PhO_3—(BO_3 if the solution be concentrated)—$\overline{O}$,HO—HCl—HBr—HI—IO_5—SiO_3—CrO_3—AsO_5—BrO_5 (Observations *m* to *s*)—HCy—$HCyS_2$—H_2Cy_3Fe—$H_3Cy_6Fe_2$ (Observation *t*).—Digest the precipitate in dilute NO_5.

Does NOT DISSOLVE Completely, or at all.

HCl—HI—HBr—HCy—$HCyS_2$—H_2Cfy—BrO_5—IO_5.—Wash the insoluble precipitate (treat the filtrate as if the precipitate had dissolved), and heat it with a pretty large excess of NH_3.

Does NOT Dissolve Completely, or at all.

(Observations *u, v.*) Filter, and treat the filtrate as if the precipitate had dissolved. HI—CyS_2.

To a portion of the original solution add NO_5, and a solution of starch, in the cold.

Blue.

Presence of Iodide. HI. (See TABLE VII., Observation *p'.*)

HI.

To another portion of the original solution add Fe_2Cl_3.

Blood Red Colour.

Sulphocyanide. $HCyS_2$.

$HCyS_2$.

DISSOLVES Completely.

HCl—HBr—HCy—BrO_5—IO_5.
To this solution of the precipitate in NH_3 add an excess of NO_5. (Observation *x.*)

REPRECIPITATED.

Dry a portion of the precipitate, mix it with pulverized $KO,2SO_3$, put it into a glass tube, and apply heat.

Purple Fumes.

Iodate. IO_5.

IO_5.

Test another portion of the dry precipitate with SO_3,HO, *in the cold.*

Hyacinth Red Fumes.

and if a red-hot splinter is plunged into the tube,

Rekindles.

Treat the mass in the tube with about ten times its bulk of water, add a little ether, shake, cork up, and leave at rest. The ether will be found floating, with a tinge of brown. (See TABLE VII., Cols. 22, 23.) BrO_5.

BrO_5.

If NO Br nor I have been found.

Wash the precipitate, transfer it, whilst still moist, to a porcelain crucible, dry it, and ignite it in a small glass test-tube (Observation *y*), boil the residue with NO_5, filter.

A Residue is left.

AgCl. Treat this residue as directed in TABLE XIII., Col. 3. HCl.

HCl.

The Filtrate.

Add to the filtrate some HCl.

White.

Presence of Cyanide. HCy. Confirm by testing the original solution by FeO,SO_3 $+KO+$ HCl, and also by NH_4S_5, as described in the test for HCy.

HCy.

If Br or I have been found.

Test the original solution by FeO,SO_3+ a few drops of Fe_2Cl_3+ an excess of potash+ an excess of HCl.

Prussian Blue.

HCy. Confirm by testing with NH_4S_5, as described in the tests for HCy.

Blood Red.

HCy. (See TABLE VII., Col. 20.)

HCy.

To another portion of the original liquid add an excess of a solution of 1 part of crystallized CuO,SO_3 $+2\cdot\frac{1}{4}$ parts of crystallized FeO,SO_3.

Dingy White (Cu_2I).

Having thus removed the iodine, remove the excess of FeO,SO_3+CuO,SO_3 by solution of KO, filter, evaporate to dryness, mix with $KO,2CrO_3$, pulverize the mass, and introduce it into a glass tube, pour upon it SO_3,HO, and proceed as directed, TABLE I.—C., Cols. 27, 28.

Brown Fumes.

HBr.

HBr.

Blood Red Liquid distils.

HCl.

HCl.

DISSOLVES Completely.

Presence of PhO_5—$\overline{O}$,HO—BO_3—AsO_5—AsO_3—SiO_3—CrO_3—

All these acids will have been detected before. With respect to SiO_3 proceed as follows:—Evaporate a portion of the original solution (*previously acidified*) to perfect dryness, drench the dry residue with concentrated HCl, and after about a quarter of an hour's digestion, add hot water, and decant; if a gritty insoluble

White Powder

is left, it is SiO_3.

SiO_3.

The neutral liquor filtered from the precipitates produced by BaO,NO_5, and by AgO,NO_5, or in which these reagents may have failed to produce a precipitate, may still have contained NO_5 or ClO_5 originally.

Mix a portion of the original solution in HCl with one-fourth of its bulk of concentrated SO_3,HO, cool the mixture, and then add a small crystal of FeO,SO_3.

Brown tinge round the Crystal.

Confirm by adding a few shavings of clean copper to another portion of the original solution in a test-tube, add concentrated SO_3,HO, and boil.

Ruddy Fumes.

NO_5.

NO_5.

Put some of the original pulverized compound in a test-tube, add moderately dilute HCl, and boil; if a gas of a

Deep Yellow Colour,

and a pungent odour resembling chlorine is produced, presence of ClO_5. This gas explodes in contact with flame. Confirm by colouring the original solution with indigo (solution in SO_3), and add solution of SO_2, carefully to the liquid.

Decolorized.

See the other reactions of ClO_5. (Observ. *z.*)

ClO_5.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

OBSERVATIONS ON TABLE XXI.

a. If the aqueous solution was sufficiently concentrated, and contained an alkaline silicate, the addition of NO_5 will produce a white precipitate, or rather white flakes of gelatinous silica; or, if it was dilute, the silica will remain in solution, and in that case *the liquor will* filter very slowly. The acid liquor should then be evaporated to perfect dryness, and the residue, being treated with HCl, will leave SiO_3, which, after filtering, will be obtained in the state of a white, gritty, insoluble powder.

b. If, after having treated the liquor by HS, filtered, if necessary, and heated the liquor, or the filtrate, in order to expel the HS, the addition of NH_3 produces a precipitate, the presence of alumina, of sesqui-oxyde of chromium, of iron, of cobalt, or of per-phosphates, oxalates, and arseniates of earths, or either of them, is certain. These will, however, have been detected in TABLE XVIII., Col. 4, 6, 8, 9, 10, 11, 12, 13. Borates of earths are also precipitated from such a solution when it does not contain a sufficient quantity of ammoniacal salt, and will, in that case, have been detected in TABLE XVIII., Col. 6.

c. It is necessary to concentrate the liquor in a suitable manner, because borates, arseniates, and arsenites are not precipitated by BaO,NO_5, as directed below, in dilute solutions; nor yet in solutions which contain a sufficient quantity of ammoniacal salts.

d. If the liquor is that resulting from the examination for bases filtered from the precipitates produced by HS, by NH_3, and by NH_4S, or in which these reagents failed to produce a precipitate, it is clear that such a liquor may at once be employed for the examination of acids, always taking care that it be first neutralized either by NH_3, or by NO_5, as the case may be, before testing for acids. *

e.†If silver, mercury, or lead, have been found in the examination for the bases, there will be no occasion to look here for CO_2—BO_3—PhO_5—SiO_5—AsO_5—AsO_3; nor for S, since the salts which result from the combination of these substances are insoluble in water.

Sulphate of silver is soluble to a certain extent in water.

Fluoride of lead is soluble, but the neutral fluoride of that metal is insoluble in water.

Sulphate of lead is insoluble in water, or nearly so.

If the addition of HCl in the examination for bases, evolved an odour of HS without causing a deposit of sulphur, then the operator has to deal only with simple sulphurets of alkalies, since the other sulphurets are insoluble in water. But if the odour of HS has been accompanied by a deposit of sulphur, then the compound contained a poly-sulphuret, or a hypo-sulphite, or a sulphite mixed with a sulphuret of alkali.

f. In the preliminary examination, and when searching for bases, the presence of CO_2—HS—SO_2—AsO_3—AsO_5—$\overline{Bz}$,HO—CrO_3—HCy, &c., TABLE I.—C., and TABLE I.—D., will have been detected.

AsO_3 will have been distinguished from AsO_5 in TABLE XVI., Col. 2, 3.

CrO_3 will have been found at TABLE XVIII., Col. 9.

If the compound is found, by the operations described in this Table, or by previous experiments, to contain CO_2—AsO_3—AsO_5—PhO_5 3HO—BO_3—SiO_3, then these acids cannot exist in the compound in any other state than that of carbonates, arsenites, arseniates, phosphates, borates, and silicates *of alkalies*, since the other salts of these acids are insoluble in water, yet

Arsenite of baryta (BaO, AsO_3)
Arsenite of strontia (StO, AsO_3)
Arsenite of magnesia (MgO, AsO_3)
} are slightly soluble in water.

Phosphate of magnesia ($\overline{2MgO}$, HO, PhO_5) is soluble in fifteen parts of water.

If, however, the solution under examination have an acid reaction, per-phosphates, oxalates, borates, or fluorides of earths may be present, but as they are precipitated on neutralizing the excess of acid, they will have been detected whilst looking for bases in TABLE XVIII., Col. 7 to 12.

If nothing but heavy metallic oxydes have been found, it is useless to look for sulphur, since all the sulphurets of those metals are insoluble in water.

If Ba—St, only have been found, it will be useless to look for SO_3, since StO,SO_3 is almost insoluble; BaO,SO_3 is altogether so.

If Au only has been found, do not look for either SO_3 or HFl, because there is no sulphate nor fluoride of gold.

If Ca only has been found, SO_3 *may* be looked for, since CaO,SO_3 is slightly soluble in water (one in about 400); but it will be useless to look for HFl, since CaFl is insoluble in water.

If Mg only, the compound contains no Fl, since MgFl is insoluble in water.

If AgO—Hg_2O, do not look for Cl, since AgCl and Hg_2Cl are insoluble in water.

PbCl is only sparingly soluble in water.

Pb_2Fl is soluble, but the neutral fluoride PbFl is almost insoluble in water.

If Bi,—Sb,—HgO, have been found, and if a milkiness or a white precipitate have been produced, on diluting the solution of the compound with water, the compound was probably a chloride, or a sulphate, since the sulphate of bismuth, of per-oxyde of mercury, and of antimony, the chloride of bismuth, of antimony, and the proto-chloride of tin, are decomposed by water. These salts, however, can hardly be said to belong to this Table.

If Fe,—Co,—Ni,—Zn,—Cd, have been found, do not look for Fl, the fluoride of these metals being insoluble, or nearly so, in water.

g. It often happens that, on attempting to wash the precipitate produced by BaCl, the filtrate passes milky through the filter, owing to a peculiar condition of the sulphate of barytes, which this reagent will have produced in presence of SO_3: this takes place more especially with neutral liquors having a certain degree of concentration; but as it never takes place in very dilute, or in very concentrated, or in acid solutions, the operator should put the rest of the solution in either of these states before he proceeds to add BaCl as described. See TABLE VII., Obs. *p*, *q*, *v*. ‡

Group 4 *to* 9.

h. It is necessary to boil for two or three minutes, after having added CaCl to the neutral solution, because phosphites sometimes fail being precipitated by that reagent, except after boiling. §

i. (Col. 6 to 9.) The precipitate produced by CaCl, and which an excess of $\overline{A}$,HO dissolves, may also be due to the presence of an ARSENIATE, though arsenic acid will probably have been detected whilst testing for the bases. The operator may, however, even at this stage of the process, satisfy himself of the presence or absence of that compound, by adding an excess of KO to the solution of the precipitate in $\overline{A}$,HO, which will reproduce the precipitate; boiling, filtering, supersaturating the filtrate with NO_5; adding AgO,NO_5 as long as a precipitate is produced, filtering, adding to the filtrate a drop or two more of AgO,NO_5, and then as much NH_3 as is necessary, nearly but not quite, to neutralize the acid, when a *brick-red* precipitate of arseniate of silver will be produced, if AsO_5 be present.

j. (Col. 6, 7.) We have already had occasion to remark that borate of barytes is soluble in solutions of ammoniacal salts, and as, in the present case, the solution contains such salts, a borate may, therefore, be present, although no precipitate may have been produced by BaCl.

k. (Col. 8, 9.) The boiling may take place in a porcelain capsule or glass beaker, and if enough KO,$\overline{A}$, or NaO,$\overline{A}$ has been added, a bulky reddish brown precipitate will subside, which is peroxyde of iron combined with all the phosphoric acid. This precipitate should be collected on a filter, washed thoroughly with boiling water, redissolved in a little HCl, mixed with an excess of $\overline{T}$,2HO to keep the iron in solution, and an excess of NH_3 added. If now, MgO,SO_3 be added to the clear yellow liquor thus obtained, and the whole *boiled*, a crystalline white precipitate of ammonia-phosphate of magnesia will fall down. See also TABLE XI., Observation *m*; XXII.—A., Obs. *n*.

The sulphur or milkiness deposited or produced by the addition of a solution of SO_2 to that of a phosphite, often takes a little time for its formation. If the solution of the compound thus tested for PhO_3, contains arsenic or arsenious acids, the addition of SO_2 will, besides a separation of S, yield a yellow sulphuret of arsenic.

Group 11 *to* 20.

l. If AgO,NO_5 produces no precipitate in this second portion, then the liquor does not contain any, HCl—BO_3—PhO_5—CrO_3—SiO_3—$\overline{O}$,HO—$\overline{T}$,2HO—$\overline{Ci}$,3HO. ‖

m. If the precipitate produced by AgO,NO_5 is YELLOW, PhO_5—AsO_3—SiO_3 should be particularly looked for, though PhO_5 will already have been detected in Col. 8, and AsO_3 in TABLE XVI., Col. 2 and 7, or TABLE XV., Col. 5.

n. If that precipitate is BRICK-RED, the solution probably contains AsO_5, though that acid can hardly exist in the solution, from which it will have been completely precipitated by HS at the very beginning, especially if the liquor has been allowed to stand in a warm place for a sufficient length of time. Yet forasmuch as AsO_5 takes some time for its precipitation by HS, especially if no SO_2 has been added to the solution for the purpose of converting it into AsO_3, which is much more readily precipitated by HS, it is possible that a little AsO_5 may still remain in solution.

o. If that precipitate be BROWNISH-BLACK, or black, PhO_3, or if the solution be dilute, BO_3 must be carefully looked for. Pyrogallic acid may also be present.

If that precipitate be white, it indicates the presence of IO_5—HCl—BO_3—BrO_5—HCy.

p. If that precipitate be YELLOWISH, or white tinged with yellow, probable presence of HI.

q. If WHITE, becoming dingy or yellowish, look particularly for HBr.

r. If REDDISH-BROWN, like precipitated Fe_2O_3, look for ferri-cyanides.

s. If CRIMSON RED, a chromate is probably present, but CrO_3 can hardly exist in the solution under present examination, for it will doubtless have been precipitated by NH_3, after reduction to the state of Cr_2O_3 by the current of HS employed.

t. If the precipitate produced by AgO,NO_5 be due to the presence of a ferro, or of a ferri-cyanide, (H_2Cy_3Fe—$H_3Cy_6Fe_2$), the original solution should be tested with a per-salt of iron, and another portion

with a proto-salt of copper; if the first of these reagents produces a blue precipitate, a ferri-cyanide is present; if the second produces a crimson or pinkish precipitate (according to the state of dilution of the liquor), a ferro-cyanide is present.

u. (Col. 11, 12.) If the precipitate produced by AgO,NO_5 in the solution under examination, is insoluble in NH_3, and has a slight yellowish tinge, it is certainly due to the presence of an iodide in the compound.

v. The operator must not be in a hurry to conclude that the precipitate produced by AgO,NO_5 is insoluble in hot NH_3, because AgBr, though soluble in that menstruum, is much less so than AgCl. The presence of AgBr is, however, easily recognized, because as it is the last to dissolve, it then appears with its characteristic yellow tinge, provided its quantity is not too small, or that of the AgI, which may have been produced at the same time, is not too large; but if a little hypo-chlorite of lime be added to the liquor, it assumes immediately a yellow, or even a brown tinge, due to a liberation of bromine; and if a little ether be added thereto, and the whole be vigorously shaken, and left at rest for a few moments, the ether will float with a yellow or brown colour, due to the bromine which it holds in solution, and which may be identified as bromine, by treating the ether with KO, &c., as described in the tests for HBr.

x. (Co^l. 13 to 20.) If the compound contained an iodate and a sulphite, the SO_2 disengaged by the addition of NO_5 to the liquor, will liberate iodine, and consequently give the characteristic blue colour when subsequently treated by a solution of starch, just as if an iodide was present, instead of an iodate.

y. (Col. 15, 16.) By igniting the white precipitate, which may consist of chloride and of cyanide of silver, the latter is decomposed, the metal being thereby reduced, whilst the chloride of silver remains in an insoluble state. During the ignition, cyanogen is evolved, and may be recognized by its odour; if that evolution is sufficiently abundant, the gas may be inflamed, and it will then burn with a flame of a characteristic peach-blossom colour.

z. This last reaction, namely with solution of indigo, is available only when the liquor contains no nitrates; if it does, all the chlorides should be first removed by an excess of AgO,NO_5, and to the liquor filtered therefrom an excess of pure KO being added, the whole is evaporated to dryness in a small porcelain capsule, and ignited therein; the dry mass being then treated with water, the solution thus obtained will be precipitated by AgO,NO_5, because the chlorate will have been decomposed, and a chloride of potassium formed.

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* *d.* If the filtrate contains NH_4S, the addition of NO_5 thereto will produce a milkiness due to a separation of sulphur, resulting from the decomposition of the excess of NH_4S in the filtrate; it will therefore be necessary to boil the liquor in order to expel the HS, and to filter it in order to separate the sulphur before proceeding with the analysis of the acids. Bear in mind, however, that the boiling with NO_5 will have oxydized a portion of the sulphur, and produced a certain quantity of sulphuric acid, so that the subsequent finding of that acid will, of course, be no proof that it existed originally in the compound. It is therefore necessary to supersaturate another portion of the liquor which contains NH_4S with HCl, instead of NO_5, boli, fiilter, and test, for SO_3 with BaCl as described: or the operator may boil the liquor which contains NH_4S with BiO,HO, filter, to separate the black sulphuret of bismuth, and the filtrate is then in a fit condition for testing with AgO,NO_5, &c., as described in the Table from Cols. 11 to 22.

† *e.* It is absolutely necessary to neutralize the liquor exactly, because from an acid solution BaCl, or BaO,NO_5, would precipitate nothing else than SO_3,HO.

‡ *g.* If the liquor contains a sulphite, the dissolving of the precipitate (BaO,SO_2) by the HCl employed, will be accompanied by a disengagement of SO_2, recognizable by its characteristic odour; and if NH_3 be next added to the acid liquor to alkaline reaction as directed, a white precipitate is immediately produced, which precipitate is insoluble in acids, and is, in fact, sulphate of barytes, because a portion of the sulphurous acid of the solution will have been converted into sulphuric acid. This precipitate, however, need not be separated; the CaCl being added, notwithstanding. It is true that the HCl employed will fail in dissolving it afterwards, but the only confusion possible is its being, *à priori*, mistaken for a fluoride; but the reaction of fluorides is so peculiar and characteristic that an error, *à posteriori*, in this respect is inadmissible.

§ *h.* The operator may also mix the solution of the precipitate in HCl with an excess of a solution of alum, and on slightly supersaturating with NH_3, the phosphoric acid will be entirely precipitated in the state of phosphate of alumina, in which the phosphoric acid may be detected, by treating it as described in TABLE XVIII., Col. 1. The other acids may be looked for in the liquor filtered from the phosphate of alumina by the processes indicated in the TABLE. The presence of BO_3 and of HFl, however, may be detected by simply evaporating that filtered liquor to dryness, and treating the dry residue, or indeed a portion of the original and well-pulverized compound, according to Cols. 4 and 7 of this TABLE. See also TABLE VII., Observation *v*.

‖ *l.* Instead of this second portion, the liquor from which all the precipitates produced by BaO,NO_5 has been separated by filtering, may be used.

TABLE XXII.—A.

Systematic Analysis of MIXED COMPOUNDS which are SOLUBLE IN WATER, and which may contain ORGANIC and INORGANIC ACIDS at the same time.

If the preliminary examination, or the systematic analysis for bases has shown the presence of CO_2—HS—SO_2—S_2O_2, supersaturate a portion of the solution with HCl (Observation *a*), or NO_5, and boil until these acids are expelled (Observations *b*, *c*), the addition of HCl may, of course, produce a precipitate of Hg—Ag—Pb—($\overline{Bz}$,HO, Observation *d*), which, however, will have been detected at the beginning. TABLE XIV., Col. 2 to 8.

If the solution contains ammoniacal salts, boil a portion of it with excess of KO until all odour of NH_3 has disappeared, neutralize with NO_5, and keep it for the examination of BO_3—$\overline{T}$,2HO—$\overline{Ci}$,3HO; this will be the SPECIAL SOLUTION referred to in Col. 20. (Observation *e*.)

Through the liquor under examination, and acidified slightly with NO_5, pass a stream of HS *to supersaturation*, and filter if necessary. Boil the filtrate, or the liquor not precipitated by HS, until all odour has disappeared, and add thereto an excess of NH_3, filter again if necessary, and to the filtrate, or to the liquor not precipitated by these reagents, add NH_4S as long as a precipitate is produced, filter if necessary, supersaturate with NO_5, concentrate by heat the filtrate, or the liquor which has not been precipitated by the above-mentioned reagents (Observation *f*); and, at any rate, boil until all odour of HS has vanished, and divide into three portions.

1ST PORTION.

To the clear solution, to which as much NH_3 or NO_5 is added, as the case may be, as is necessary to impart or leave to it a *slight* alkaline reaction (filtering if necessary), add further a solution of BaCl, and apply heat. (Observation *g*.)

Special Solution.

2ND & 3RD PORTIONS.

NO PRECIPITATE.

Possible presence of BO_3,—$\overline{O}$,HO,—$\overline{T}$,2HO,—$\overline{Ci}$,3HO. (Observ. *h*.)

Go to Col. 20. and also possible presence of NO_5—ClO_5—ClO.

See TABLE XXII—B.

A PRECIPITATE is produced.

Probable presence of SO_3—PhO_5—PhO_3—CrO_3—SiO_3—BO_3—AsO_3—AsO_5—$\overline{O}$,HO—$\overline{T}$,2HO—$\overline{Ci}$,3HO—$\overline{M}$,2HO—HFl—(IO_5, see Observation *i*)—$\overline{Qt}$,3HO—$\overline{G}$,3HO—$\overline{Me}$,3HO.

Dry a portion of the precipitate, mix it with pulverized $KO,2SO_3$ (about twice its bulk), and apply the heat of a spirit-lamp.

Violet Fumes.

IO_5.

IO_5.

Does NOT dissolve completely.

Separate the insoluble portion by filtering and treat the filtrate, of course, as if the precipitate had dissolved completely in HCl. Fuse the insoluble residue with NaO,CO_2 on a charcoal support, remove the fused mass, or the portion of charcoal on which it rested, put it on a clean piece of silver, and moisten with dilute HCl.

Odour of HS.

Brown Stain.

SO_3.

See TABLE VII., Ob. *s*, *t*.

SO_3.

Digest for a while the precipitate in HCl, and dilute with water.

DISSOLVES Completely.

To this solution of the precipitate in HCl add as much NH_3 as will impart a very slight alkaline reaction to the liquor, and then add CaCl *in the cold.*

O.

$\overline{M}$,2HO — $\overline{Ci}$,3HO, ($C_2H_4O_8$,2HO)-($C_{12}H_5O_{11}$,3HO)

Boil the whole, and filter if necessary (Observ. *j*) while it is boiling hot.

O.

To this neutral filtrate, or liquor, add alcohol. (Observ. *k*.)

White.

Dry this precipitate and ignite it in a glass test-tube, the residue is CaO,CO_2 mixed with charcoal. Treat another portion of the liquor with $PbO,\overline{A}$ and boil.

White viscid Precipitate.

$\overline{M}$,2HO.

$\overline{M}$,2HO.

White.

$\overline{Ci}$,3HO.

To another portion of the liquor add $PbO,\overline{A}$ in excess.

White, Curdy.

Very sparingly soluble in NH_3. Very soluble in citrate of ammonia.

$\overline{Ci}$,3HO.

$\overline{Ci}$,3HO.

White, or Whitish Precipitate.

$\overline{O}$,HO—$\overline{T}$,2HO—HFl—$\overline{Ci}$,3HO—$\overline{M}$,2HO—PhO_5—PhO_3—BO_3—AsO_5.

Separate by filtering, and treat the filtrate as directed in Col. 4, 5, previously adding a little more CaCl thereto. Divide the precipitate into two portions.

1ST PORTION.

Digest in a large excess of $\overline{A}$,HO in the cold.

DISSOLVES completely

PhO_5—PhO_3—BO_3—AsO_5. Add excess of NH_3.

O.

Certain absence of PhO_5. Possible presence of BO_3. Treat a small portion of the original compound with SO_3,HO + alcohol and inflame. (Ob *a*, *l*,)

Greenish Yellow Flame.

BO_3.

BO_3.

RE-PRECIPITATED.

Mix a portion of the precipitate with SO_3,HO + alcohol and inflame.

Greenish Yellow Flame.

BO_3.

BO_3.

Take a portion of the precipitate and boil it with excess of KO, for about a quarter of an hour, filter, supersaturate the filtrate with NO_5, and add AgO,NO_5 as long as a precipitate is produced, filter, add to the filtrate a drop or two more of AgO,NO_5, and then as much NH_3 as is necessary to nearly neutralize the acid.

Light Brown.

AsO_5. (Ob. *m*.)

AsO_5.

Redissolve the precipitate in $\overline{A}$,HO, and divide into two portions.

1ST PORT. Take a little of that portion, and treat with KO,$\overline{A}$—Fe_2Cl_3—$\overline{T}$,2HO—NH_3 and MgO,SO_3, as described in TABLE XXI., Col. 8.

White.

(Observ. *n*.)

PhO_5.

2ND PORT, Take a little of that portion, neutralize it nearly with NH_3, and add AgO,NO_5.

Brown.

By boiling

Black.

PhO_3.

To the original solution of that portion add SO_2, and heat gently.

Milkiness from sulphur.

PhO_3.

Does NOT dissolve completely.

$\overline{O}$,HO—HFl. Add HCl to the precipitate.

Dissolves.

$\overline{O}$,HO.

To this solution add NH_3.

Re-precipitated.

$\overline{O}$,HO.

To a portion of the original solution of the compound prepared as above said, at the beginning of the Table, and consequently neutral, add saturated solution of CaO,SO_3. (Observ. *o*.)

White.

Sol. in HCl. See also TAB. XXI., Col. 5.

$\overline{O}$,HO.

Does NOT Dissolve.

Filter and treat the filtrate as if the precipitate had dissolved. Put a portion of the precipitate in a platinum crucible with SO_3,HO, and cover the crucible with a piece of glass waxed over, and bearing tracings, as described in tests for HFl.

Corrosion.

HFl. See TABLE VII., Ob. *w*.

HFl.

2ND PORTION.

Digest in excess of KO, shaking from time to time.

Dissolves.

$\overline{T}$,2HO. Boil.

White Precipitate re-appears.

$\overline{T}$,2HO.

See Dictionary and also TAB. VIII. Obs. *c*, *d*.

$\overline{T}$,2HO.

Does NOT Dissolve.

BO_3—AsO_5—PhO_5—$\overline{O}$,HO—HFl.

Filter, and treat the filtrate as if the precipitate had dissolved, that is, as at Col. 13.

Take a portion of the insoluble precipitate and treat it with SO_3,HO + alcohol, and inflame

Greenish Yellow Flame.

BO_3.

See Dictionary, and TABLE VII., Observ. *a'*.

BO_3.

Treat the precipitate with a large excess of $\overline{A}$,HO.

Dissolves.

AsO_5,—PhO_5,—PhO_3,—BO_3.

Treat as directed in Col. 7 to 10.

Does NOT Dissolve.

$\overline{O}$,HO, HFl.

Treat as directed in Col. 11, 12.

To another portion of the neutral solution add Fe_2Cl_3.

Black.

$\overline{Qt}$,3HO—$\overline{G}$,3HO.

To another portion of the neutral solution add solution of gelatine.

Curdy Precipitate.

$\overline{Qt}$,3HO.

Filter and treat the filtrate as if no precipitate had been produced, that is as in Col. 18.

See the Observ. in TAB. VIII. Col. 4.

$\overline{Qt}$,3HO.

O.

$\overline{G}$,3HO.

To the liquor not precipitated by gelatine, or to the filtrate from that produced by it, add Fe_2Cl_3.

Black.

$\overline{G}$,3HO.

See TABLE VIII. Col. 6.

$\overline{G}$,3HO.

Blood Red.

$\overline{Me}$,3HO.

This blood-red colour is not altered by solution of corrosive sublimate. See Observation on Col. 5, TABLE VIII.

$\overline{Me}$,3HO.

$\overline{Me}$,3HO.

If the original solution contains also ammoniacal salts, and if no BO_3—$\overline{T}$,2HO—$\overline{Ci}$,3HO. have been found as yet, it will be necessary to examine the special solution alluded to at beginning of this Table, and from which the ammoniacal salts have been expelled by boiling with KO. Treat, therefore, that special solution as directed in Col. 4 to Col. 13.

Go to TABLE XXII.—B.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

OBSERVATIONS ON TABLE XXII.—A.

GENERAL REMARKS.

The preliminary examination according to TABLE I.—C., Col. 21, will have already shown the probable presence or absence of organic acids by the charring of the mass which will have been observed or not, when heating the compound with concentrated SO_3,HO, and likewise by the charring and deflagration which will have been produced, or not, when treating the compound according to the directions of TABLE I.—A, Cols. 8 to 10: yet, as several organic acids are volatilized, or are not charred by heat, and might therefore escape detection, it is well to ascertain whether such a substance is present or not, by burning it with oxyde of copper, since all organic substances, when so treated, yield carbonic acid and water. The *modus operandi* is as follows:—Take a portion of the pulverized compound, and mix it intimately with a certain quantity of oxyde of copper (See Dictionary of Reagents). Put the mixture into a glass-test tube about six inches long, and pour over the said mixture a stratum of oxyde of copper, about one inch in thickness, close the tube with a sound cork, provided with a disengagement tube plunging into a beaker containing lime-water. Expose now the contents in the tube to a red heat, by means of a spirit or gas lamp, beginning by heating first the stratum of oxyde of copper, and then the compound under examination, and which lies at the bottom of the tube; if an organic matter is present, a disengagement of CO_2 will take place, which will, of course, produce a white precipitate in the lime-water of the beaker. It is almost superfluous to observe that the operator should previously ascertain that the compound under examination does not contain any carbonates, or if it does, their carbonic acid must, of course, be first eliminated in the most complete manner before submitting it to the above treatment.

a. If the preliminary examination, TABLE I—C, or the systematic analysis, TABLE XIV., has shown the presence of CO_2—HS—SO_2—S_2O_2, addition of HCl will, of course, expel them; but then the liquor will become unfit for the detection of any HCl which may be present; wherefore, another portion of the liquor to which no HCl has been added, should be especially tested for that acid.

b. Remember that if the solution contains free BO_3, boiling will expel a considerable portion, and perhaps the whole of it, since this acid begins to volatilize with the aqueous vapour even before the water boils. A portion of the solution treated by HCl had, therefore, better be at once neutralized by KO, evaporated and specially tested for BO_3 by drenching the residue with concentrated SO_3HO in a small capsule, pouring alcohol, or naphtha, upon the mass, heating and inflaming the spirituous mixture, when the edge of the flame will assume the fine golden-green colour, which is characteristic of the presence of BO_3.

c. The present solution cannot contain any other borates but those of alkalies, since all other borates are insoluble in water; but if the solution was acid in the first instance, of course borates of other bases may be contained therein. See also the observations at the beginning of TABLE XXI; VII., Obs. *p*, *q*, *v*.

d. Benzoic acid may be summarily detected in the precipitate which HCl may produce in the solution, by separating that precipitate, and heating it in a glass test-tube, or on a platinum foil, when it will volatilize either wholly, or in part, with the characteristic odour of benzoic acid, which acid will doubtless have been already detected, as well as BO_3, either in the preliminary examination for acids, TABLE I—C, or at the beginning of the systematic analysis, TABLE XIV., Col. 2, 3.

e. It is necessary to decompose the ammoniacal salts present in the solution by boiling it with KO, as stated, because the borates, tartrates, and citrates of earths are soluble in ammoniacal salts, and might, therefore escape detection.

If the solution was acid in the first instance, and contained phosphates, arseniates, or oxalates of earths, this addition of KO, to decompose the ammoniacal salts which may be present, or if no such salts exist in the liquor, the subsequent addition of NH_3 to supersaturation, or even to neutralization, will of course produce a precipitate, as already alluded to in TABLE V., Observation *d*, and the precipitate in that case must be examined accordingly, as directed in the systematic analysis of compounds insoluble in water, but soluble in acids, namely, TABLE XXIV. The precipitate thus produced in the first instance may, however, be examined as directed in the present Table, Cols. 8 to 10. As to oxalic acid the precipitate may be dried and then heated in a glass test-tube with concentrated SO_3 + MnO_2, as described in the tests for oxalic acid. See Dictionary.

f. Since the solution so prepared will have been treated by NH_3, the operator will doubtless have to treat it in the same manner as the special solution alluded to at the beginning of this Table, for the reasons related in Observation *e*.

g. If BaCl produces a precipitate, it is a sign that the acids mentioned in this Table, or either of them, are present; but if the liquor has been treated *seriatim* by HS—by NH_3—by NH_4S, as directed at the beginning of the Table, several of them, namely, CrO_3—AsO_3—AsO_5, &c., cannot exist in the solution, though, if the solution saturated with sulphuretted hydrogen has not stood long enough in a warm place, AsO_5 may be present in it, especially if it have not been converted at the beginning into AsO_3 by an addition of SO_2, as already alluded to (see TABLE IV., Observation *c'*). (See TABLE VII., Obs. *p*, *q*, *v*.)

Group 1.

h. (Col. 1.) If an ammoniacal salt be present in sufficient abundance (which will probably be the case in the present instance), it may happen that no precipitate may be produced by BaCl, although oxalates, borates, tartrates, and citrates be present, since the salts which baryta forms with these acids are soluble in solutions of ammoniacal salts, as we already said.

i. With respect to iodic acid (IO_5), the operator must recollect that unless the liquor be in a concentrated state, BaCl will fail in producing a precipitate, *although a soluble iodate may be present.* But if the solution be in a concentrated state, an immediate precipitate is formed; if more dilute, some time will elapse before it makes its appearance.

Groups 2 *to* 19.

j. (Col. 4—5.) It may happen, in boiling the liquor to which CaCl has been added, that the precipitate produced, instead of being due to the presence of $\overline{Ci},3HO$, will be due to that of PhO_3, since phosphites sometimes fail in being precipitated by CaCl except by boiling; but the test with AgO,NO_5 places the presence of a phosphite beyond possibility of doubt.

k. (Col. 4.) Do not hasten to conclude that because CaCl has produced no precipitate either in the cold or by boiling, whilst the addition of alcohol has caused a precipitate to appear, that it is, therefore, due to the presence of malic acid, since many aqueous solutions of salts of lime, as, for example, borate, seleniate, sulphate of lime, and a few others, which are sparingly soluble, or quite insoluble in alcohol, would, on being treated by CaCl, with addition of alcohol, produce a precipitate. It is, therefore, only when the presence of these acids has been disproved, that that of malic acid may be *presumed*, for in this case more than in any other, it is necessary not to omit to apply the special tests for malic acid.

l. (Col. 6.) If the original compound is a liquid it must be first mixed with KO before evaporating to dryness, for the purpose of testing for BO_3 with concentrated SO_3 + alcohol, for the reasons which are already stated in Observation *b* of this Table.

m. (Col. 8.) The presence of AsO_5 is not very likely, for this acid will probably have been precipitated by HS at the beginning; yet, for as much as AsO_5 is not speedily separated by that reagent, the liquor may still retain some of it, and in that case it will be detected, as set forth in the Table. (See the Dictionary AsO_5.)

n. (Col. 9.) It is necessary to boil the liquor *for some time* after addition of MgO,SO_3, because this reagent does not produce a precipitate in cold solutions of phosphates, even when neutral; but, after boiling for some time, a precipitate of magnesia is gradually produced, which does not disappear in cooling, and is insoluble in ammonia and ammoniacal salts, but is soluble in free acids.

o. (Col. 11.) The solution of the compound should not, however, be acid, since oxalate of lime is soluble in acids, neither should it, of course, contain any salt of baryta, or of strontia, since solution of sulphate of lime would evidently produce then a white precipitate of BaO,SO_3 or StO,SO_3; but such precipitates being insoluble in acids could not be mistaken for one of oxalate of lime. Attention being paid to these Observations, sulphate of lime is the best test for oxalic acid and its salts, for there is no other acid which under such circumstances would produce the precipitate in question. It is sometimes necessary, however, to allow a little time to elapse, for when the quantity of oxalic acid is small, a few minutes are required for the turbidness to appear.

TABLE XXII.—B.

Systematic Analysis of MIXED COMPOUNDS which are SOLUBLE in WATER and which may contain ORGANIC and INORGANIC ACIDS at the same time.

2ND PORTION. (From TABLE XXII.—A.)

To the second portion of the solution *exactly* neutralized, as said in TABLE XXII.—A, with NO_5, or with NH_3, as the case may be; add now AgO,NO_5, and filter if necessary, treating, of course, the filtrate as if this reagent had produced no precipitate. (If HCl has been used at the beginning, of course. another portion of liquor to which no HCl has been added, must be especially tested for that acid.

3RD PORTION. (From TABLE XXII.—A.)

To another portion of the original solution previously neutralized *exactly* as before said, or to that portion of the solution in which CaCl failed to produce a precipitate, or which was filtered from the precipitate produced by that reagent, add Fe_2Cl_3.

O.

Examine the liquor or the filtrate, as directed in Col. 3, and 19 to 21.

A PRECIPITATE is produced. (See Observations on TABLE XXI., Col. 11 to 20.)

Boil a portion of the liquor containing the precipitate in suspension.

PhO_5—PhO_3—(BO_3, If the solution is concentrated)—$\overline{O}$,HO—HCl—HBr—HI—HCy—IO_5—$HCyS_2$—H_2Cfy—SiO_3—CrO_3—BrO_5—AsO_5. (Observations on TABLE XXI., Col. 11 to 20.) Digest the precipitate in NO_5.

Brown or Black Precipitate,

which is reduced metallic silver.

$\overline{Fo}O_3$,HO.

Confirm by adding some HgO,NO_5 to another portion of the solution.

Metallic mercury is reduced.

$\overline{Fo}O_3$,HO.

Dissolves completely

PhO_5—$\overline{O}$,HO—BO_3—AsO_5—AsO_3—CrO_3—SiO_3.—

All these will have been detected before, except perhaps, SiO_3, for the detection of which proceed as follows. Evaporate a portion of the original solution (previously acidified) to perfect dryness. Drench the dry residue with concentrated HCl; after about a quarter of an hour, add hot water, and decant; if an

Insoluble White gritty powder

is left, it is

SiO_3.

$\overline{SiO}_3$.

Does NOT Dissolve completely, or at all.

HCl—HI—HBr—HCy—$HCyS_2$—H_2Cfy—BrO_5—IO_5.
Filter, and examine the filtrate, as if the precipitate had completely dissolved. Wash the insoluble precipitate, and heat it with a pretty large excess of NH_3.

Does NOT dissolve, at least completely.

(Observations on Col. 11, TABLE XXI.)
HI—$HCyS_2$.
Filter, and treat the filtrate as in Col. 6, and following.

To another portion of the original solution add NO_5, and a solution of starch *in the cold.*

Blue.

HI.

See Observ. on TABLE XXI. Col. 11, also TABLE VII., Col. 24, Observ. *p'*.

HI.

To another portion of the original solution add Fe_2Cl_3.

BloodRed colour.

$HCyS_2$.

Add to this blood-red solution, one of corrosive sublimate.

Decolourized.

$HCyS_2$.

$HCyS_2$.

Dissolves completely.

HCl—HBr—HCy—BrO_5—IO_5.—Add thereto an excess of NO_5.

Re-precipitated.

Dry a portion of the precipitate, mix it with pulverized $KO,2SO_3$, put it into a glass tube, and apply heat.

Purple fumes.

IO_5.

Suspend a piece of paper moistened with starch into the tube; it turns

Blue.

IO_5.

IO_5.

Take another portion of the dry precipitate and add thereto some SO_3,HO in the cold.

Hyacinth Red fumes.

A red-hot splinter plunged into the tube is

Rekindled.

Treat the mass in the tube with about ten times its bulk of water, add a little ether, shake and leave at rest. The ether floating at top has a

Brown tinge.

BrO_5.
See TABLE VII., Col. 22, 23.

BrO_5.

If no BrO_5 nor IO_5 have been found,

Wash the precipitate, transfer it whilst still moist to a porcelain crucible, dry it, and ignite it in a small test-tube (Observation on Col. 15, TABLE XXI.), boil the residue with NO_5, and filter.

A residue is left.

HCl.

Treat this residue, which is AgCl, as directed, TABLE XIII. Col. 3.

HCl.

The filtrate.

Add to the filtrate some HCl.

White.

HCy.

Confirm by testing the original solution with FeO,SO_3 + KO + HCl, and also by NH_4S_5, as described in the tests for HCy, which see in Dictionary.

HCy.

If Br or I have been found.

Test the original solution with FeO,SO_3 + a drop or two of Fe_2Cl_3 + an excess of KO + an excess of HCl.

Prussian Blue.

HCy.

Confirm by testing with NH_4S_5, as described in the tests for HCy, which see in Dictionary.

Blood Red colour.

HCy.

HCy.

To another portion of the original liquid add an excess of a solution of one part of crystallized CuO,SO_3 + $2\frac{1}{4}$ parts of crystallized FeO,SO_3.

Dingy White Precipitate of Cu_2I.

Having thus removed the iodine, remove the excess of FeO,SO_3 and CuO,SO_3 employed by adding solution of KO, filter, evaporate to dryness, mix with $KO,2CrO_3$, pulverize the mass, and introduce it into a glass tube, pour then upon it some SO_3,HO, and proceed as directed in TABLE I.—C., Col. 27, 28.

Hyacinth Red fumes.

HBr.

See also TABLE VII. Col. 23.

HBr.

Blood Red liquid distils.

HCl.

See also TABLE VII. Col. 21.

HCl.

Light Brown bulky precipitate.

$\overline{Bz}$,HO—$\overline{S}$,HO.

Decant the supernatant liquor, pour excess of NH_3 on the precipitate, boil, and filter; concentrate the filtrate, add alcohol to it, and divide into two portions.

(Observation *a*.)

1ST PORTION.

To this first portion of the alcoholic filtrate add BaCl.

White.

$\overline{S}$,HO.

$\overline{S}$,HO

O.

$\overline{Bz}$,HO.

$\overline{Bz}$,HO.

Black.

$\overline{Qt}$,3HO—$\overline{G}$,3HO.

See TABLE XXII.—A. Col. 17, 18.

$\overline{Qt}$,3HO
$\overline{G}$,3HO.

Blood Red Colour.

$\overline{Me}$,3HO—$HCyS_2$.

Pour solution of corrosive sublimate.

Decolourized.

$HCyS_2$.

Colour remains unaltered

$\overline{Me}$,3HO.

See besides, Col. 5, and TABLE XXII., Col. 19.

$HCyS_2$.
$\overline{Me}$,3HO.

2ND PORTION.

Add a slight excess of HCl.

O.

$\overline{S}$,HO.

See besides, TABLE VIII., Col. 9.

$\overline{S}$,HO

Milkiness or White Precipitate.

$\overline{Bz}$,HO.

See TABLE VIII., Col. 10.

$\overline{Bz}$,HO.

Dark Red Colour.

$\overline{A}$,HO—$\overline{Fe}O_3$,HO.

Boil and leave at rest for about ten minutes.

Reddish Brown precipitate.

Neutralize a portion of the original solution with KO, evaporate to dryness, put a portion of the dry residue in a glass test tube, add concentrated SO_3,HO, and apply heat.

Odour of Vinegar.

$\overline{A}$,HO.

See Observation on Col. 11, TABLE VIII., or add to the dry residue just spoken of, some alcohol, and about one-third of the bulk of the alcohol of SO_3,HO, and boil,

Characteristic odour of acetic ether.

$\overline{A}$,HO.

$\overline{A}$,HO.

Efferescence, gas burns with blue flame.

$\overline{Fe}O_3$ HO.

Or mix a portion of the solution with SO_3,HO diluted, and condense what distils over, neutralize the distilled liquor with NaO,CO_2, and test with Fe_2Cl_3.

Blood Red colour.

Test the same distillate with AgO,NO_5.

Metal is reduced in the state of black powder.

$\overline{Fe}O_3$,HO.

If no precipitate has been produced by BaCl,
nor by CaCl,
nor by AgO,NO_5,
nor by Fe_2Cl_3,
treat the original solution (or the liquor filtered from such precipitates) as follows:—

Take a portion of the original solution, to which no NO_5, of course, has been added, add thereto one-fourth of its bulk of concentrated SO_3,HO, and drop into it a small crystal of FeO,SO_3.

Greenish Black colour

all round the crystal.

NO_5.

See Observ. on Col. 27, TABLE VII. Confirm by taking another portion of the original solution, add thereto about one-fourth of its bulk of concentrated SO_3,HO + a few clean copper turnings, apply heat if necessary.

Ruddy fumes.

NO_5.

Obs. on Col. 27, TAB. VII.

NO_5.

Take another portion of the original solution, concentrate, if necessary, add about one-fourth of its bulk of concentrated SO_3,HO *in the cold.*

Yellow coloured liquor.

Greenish Yellow fumes.

Peculiar odour resembling Cl.

ClO_5.
Confirm by mixing a portion of the dry compound, or of the residue left, by evaporating a portion of the original liquid to which no HCl has been added, with microcosmic salt, and expose it on the hook of a brass wire to the smallest possible flame of a spirit lamp.

Beautiful Blue flame.

ClO_5.

ClO_5.

To another portion of the original liquor, or solid compound with which no acid has been employed, add $\overline{A}$,HO.

Odour of Cl.

ClO.

ClO.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

OBSERVATIONS ON TABLE XXII.—B.

a. (Col. 13.) No account need be otherwise taken of this precipitate on the filter, it is only peroxyde of iron, but the filtrate contains benzoate or succinate of ammonia if benzoic or succinic acids are present.

b. (Col. 18) :—When the liquor contains both acetic and formic acids, the latter may be identified by diluting the liquor, adding HgCl (perchloride of mercury) thereto, and boiling; if a precipitate of a greyish colour is formed, it is metallic mercury. This reduction is accompanied by a disengagement of carbonic acid.

TABLE XXIII.

Systematic Analysis of MIXED COMPOUNDS which are INSOLUBLE IN WATER, but which are SOLUBLE IN ACIDS.

If the compound is in the solid state, reduce it to very fine powder, and treat it exactly as described in TABLE I.—D., E.,and TABLE II.—A, B., with a view to ascertain whether any portion of it is soluble in water, and in what acid the portion insoluble in water can be dissolved. But whatever may be the acid employed do not use much more of it than is necessary to effect the solution of the compound, or else evaporate the excess of acid by heat. (Observations *a*, *b*, *c*.)
If the compound is in the liquid state, the operations in TABLE III. must be carefully gone through. If an odour of Cl is evolved, some of the substances mentioned in TABLE I.—E., Col. 6, may be present.

If the solution of the compound is one in NO_5, add some HCl to a portion of it when cold.

NO Precipitate nor Milkiness.

Absence of Hg_2O AgO PbO(?). See Obs. *d*. Go to Col. 6, and following.

White Precipitate or Milkiness.

Add more HCl to the solution until a precipitate ceases to be produced. Wash the precipitate twice with water, and filter (Observation *d*), treating, of course, the filtrate as if HCl had produced no precipitate or milkiness.
Pour an excess of NH_3 on the precipitate, and leave the whole to digest for some little time.

Dissolves Completely.	Does NOT Dissolve Completely, or at all.	
Supersaturate the ammoniacal solution with NO_5.	But it remains	Or turns
	White.	**Black.**
	PbO, but possibly, also, AgO.	Hg_2O, but possibly PbO and AgO.

White.

Insoluble in water and in acids; immediately soluble in NH_3

Ag,—BzHO, and BO_3 may be present. Observation *e*.

AgO.

Filter, and examine the filtrate for AgO, as in Col. 2.
The precipitate insoluble in NH_3 is

White.	Black, | Blackish, or Grey.	
PbO. Confirm by fusing a portion of the precipitate previously mixed with NaO,CO_2 on charcoal before the blowpipe.	Take a portion of the precipitate, mix it with NaO,CO_2, and fuse it before the blowpipe on a charcoal support.	Take a portion of the precipitate, mix it with NaO,CO_2, and fuse it in a small test-tube, by means of the spirit-lamp, urged with the blow-pipe.
Malleable Bead.	Metallic Malleable Bead.	Globules of Mercury.
Pb. Dissolve the metallic bead in $\overline{A}$,HO, and submit the solution to the tests for Pb.	Dissolve the metal in $\overline{A}$,HO or in NO_5, and submit the solution to the usual tests for Pb.	See Observations on TABLE I.—A., Cols. 17 Obs. *u*. and TABLE XIII., Col. 1.
PbO.	PbO.	Hg_2O.

To a portion of the solution of the compound in the proper acid (TABLES I.—E. and II.—B.), or to the acid liquid, if the compound was in the liquid state, previously concentrated by heat if need be, and which must not contain too large an excess of acid as was already said, add some water (Observation *f*), and pass a stream of HS to entire supersaturation.

0.	White,	Yellow,	Red Orange,	Yellowish Orange,	Brown,	Black,	or any other Colour.
	or Yellow of various Shades.						

Go to TABLE XXIV.

If the filtrate has a

Greenish Colour,

probable presence of CrO_3. (Observat. *h*.)

CrO_3.

Treat the rest of the solution by HS to supersaturation, heat the whole nearly to boiling. (See Observations *a*, *b*, in TABLE XV.) Decant carefully (and keep the filtrate for further examination, as directed in Col. 6, if it contains anything). Wash the precipitate by decantation in a filter (throwing away the water thus decanted) until the last water no longer reddens litmus paper, and proceed with the precipitate as follows (Observation *g*):—

White.	Bluish Green.
Insoluble in HCl. S Indicating the presence of Fe_2O_3, or other of the oxydes and acids mentioned in TABLE IV., Col. 15. Ascertain whether it is S by burning on platinum foil. The solution separated from this precipitate contains now the Fe_2O_3 in the state of FeO, and will be detected, as also the other oxydes which act in the same way in TABLE XXIV.	It is S coloured by the superincumbent liquid. Presence of CrO_3. Examine whether the precipitate is S alone, by burning on platinum foil. If it burns without residue, it is S only. If a residue be left, fuse a portion of the residue on borax or microcosmic salt on platinum wire before the blowpipe.
Fe_2O_3.	**Emerald Green.** CrO_3. (Observat. *h*.) The presence of Cr will, however, be detected in TABLE XXIV.
	CrO_3.

AsO_3—AsO_5 (Observations *j*, *k*)—SnO_2—CdO—Sb—S.—Collect the well-washed precipitate on a filter, transfer a little of it to a small capsule, and pour upon it some NH_3+an excess of NH_4S containing a slight excess of S, and leave the whole to digest at a gentle heat for a few minutes. (Observation *i*.)

Dissolves Completely.	Does NOT Dissolve Completely, or at all.
AsO_3—AsO_5—SnO_2—Sb—S. Take a small portion of the precipitate produced by HS, and expose it to a red heat on a strip of platinum foil, in the flame of a spirit-lamp.	CdO—but possibly, also, AsO_3—AsO_5—SnO_2—Sb. Digest the whole of the precipitate (except a small portion which may be reserved for special testing) with NH_3+NH_4S, as was done with the small sample at first, and keep the whole at a gentle heat for about a quarter of an hour, and decant the superincumbent fluid. (Observation *i*.)

Volatilizes Completely.	Residue is left.
As—S. Mix a portion of the yellow precipitate produced by HS, previously dried, with NaO,CO_2+KCy, and introduce a small portion of the mixture into a glass tube; proceeding, in fact, as directed in the tests for AsO_3 (which see) in Dictionary.	SnO_2—Sb. See next Group.
Metallic Mirror. Odour of Garlic.	O.
To ascertain whether As existed in the solution as AsO_3 or AsO_5, pass a stream of HS through a portion of the original liquor until all is precipitated, and to this well-washed precipitate (or if there be no objection to it (Observation *l*), to that which HS has already produced, add an excess of NH_3, which will redissolve it; filter, if necessary, add to the liquor an excess of AgO,NO_5, filter, to separate the black sulphuret, supersaturate the filtrate with NO_5, and filter, if necessary; to the clear acidified liquor add a few drops more of AgO,NO_5, and then as much NH_3 as is necessary *nearly* to neutralize the acid. (Observ. *m*.)	S. Boil a portion of the precipitate with strong NO_5, and test the filtrate with BaO,NO_5.
Yellow. AsO_3. Immediately soluble in excess of NH_3 or of NO_5. AsO_3.	**Light Brown.** AsO_5. Immediately soluble in excess of NH_3 or of NO_5. AsO_5. Observ. *j*.
	White. Insoluble in water and in acids. S. (See TABLE VII., Observation *s*.)
	S.

SnO_2 Sb.

SnO—Au—Pt—Ag—Hg—Pb—Cu—Bi—but, possibly, also As—SnO_2 Cd—Sb.—Collect the well-washed precipitate on a filter, transfer a little of it to a small capsule, and pour upon it some NH_3+NH_4S, containing a slight excess of S, and leave the whole to digest at a gentle heat for a few minutes. (Observations *i*—*n*.)

Dissolves Completely.	Does NOT Dissolve Completely, or at all.
SnO—Au—Pt—but, possibly, also As—SnO_2—Sb. Digest the whole of the precipitate in NH_3+NH_4S, as was done for the sample, reserving a little of it, however, for special testing. Filter if necessary. Add an excess of HCl to the whole solution in NH_4S, so as to impart a strong acid reaction to the liquor.	If the precipitate does not dissolve *at all*, go at once to TABLE XXIV. (Observ. *n*—*q*.) If it dissolve partly, digest the whole of the well-washed precipitate at a gentle heat with NH_4S, containing a small excess of S, and after about a quarter of an hour, decant the superincumbent liquor in a filter.

A coloured precipitate is reproduced.

To a small portion of the original solution add a few drops of SnCl.

Black Precipitate.	Brown Colour.
Au.	Pt.

If the solution is dilute.

Purple Colour.	Brown Precipitate.
Au.	Pt.

To another small portion of the original solution add a few drops of FeO,SO_3.

Black.	O.
Au.	Pt.

To a *very concentrated* portion of the original solution add a few drops of NH_4Cl and of HCl.

O.	Yellow.
Au.	Pt.
Au.	Pt.

Dry the whole of the precipitate at a gentle heat, and treat it afterwards cautiously with fuming NO_5. Evaporate to syrupy consistence; remove the lumps of S; treat the syrupy mass with water, and filter.

The Filtrate.	The White Insoluble Residue.	
Add to the filtrate an excess of AgO,NO_5, filter, to the clear filtrate add a few drops more of AgO,NO_5 + as much NH_3 as is necessary, *nearly*, to neutralize it, as in Col. 14.	Wash the white insoluble residue thoroughly with water, and boil it with a saturated solution of $\overline{T}$,2HO or KO,HO,$\overline{T}$, exactly as in Cols. 15, 16, 17.	
Light Brown, AsO_5. To ascertain whether As existed in the compound as AsO_3, or AsO_5, proceed as described in Cols. 9, 10.	Dissolves Completely. Sb alone. Confirm by adding to the solution in $\overline{T}$,2HO a few drops of HCl, and then a stream of HS.	Does NOT Dissolve Completely, or at all. Filter, and boil the residue once more with $\overline{T}$,2HO, and treat the filtrate therefrom as in Col. 22. Dry the insoluble residue well, mix it with NaO,CO_2+KCy, treat it in the reducing flame of blowpipe on charcoal support.
As.	**Red Orange.** Sb. (Observation *o*.) Sb.	Metallic, Malleable Bead, looking like Silver. Sn. Dissolve the bead in HCl, and test with AuCl3. **Purple.** Sn. (Observ. *p*.)

The Filtrate	The Insoluble Residue.
May contain As—Sn—Au—Pt—Sb alone or jointly, therefore, the filtrate and the original solution as directed, Cols. 19 to 23.	Pb—Bi Cu—Hg—Ag and, possibly, Cd. Wash thoroughly, and go to TABLE XXIV. (Observ. *r*—*s*.)

Yellowish Orange, or Yellow Precipitate of various Shades reproduced.				
Treat a portion of the precipitate as directed in Cols. 9, 10, 11.	Sb—SnO_2—As. Dry the whole of the precipitate at a gentle heat, reduce it to powder, put it into a porcelain capsule, and cautiously pour upon it, by small portions at a time, some fuming NO_5, until the effervescence ceases, and nitrous acid fumes are no longer evolved. Evaporate to syrupy consistence, remove the yellow lumps of S produced, treat the syrupy mass with water, and filter.			Insoluble Residue. Mix a portion of the yellow precipitate with NaO,CO_2 +KCy, and fuse before the blowpipe on charcoal support.
	The Filtrate.	The White Insoluble Residue.		
	Add to the filtrate an excess of AgO,NO_5, if a white precipitate is produced, heat to boiling, to agglomerate it, filter, and to the clear filtrate add a few drops more of AgO,NO_5, and then as much NH_3 as is necessary *nearly* to neutralize it.	Sb_2O_5—SnO_2—either or both.—Wash the white residue thoroughly with water, boil it with a saturated solution of $\overline{T}$,2HO, or of KO,HO,$\overline{T}$.		
		Dissolves Completely. Sb alone. Confirm by adding a little HCl to this solution in $\overline{T}$,2HO filter, if necessary (Observation *o*), and through the clear filtrate pass HS.	Does not Dissolve Completely, or at all. Filter, and treat the filtrate as in Col. 15. Boil the insoluble portion with a fresh quantity of $\overline{T}$,2HO, and filter.	
	Light Brown. Immediately soluble in excess of NH_3, or of NO_5.	**Red Orange.** Sb.	The Filtrate. Add a little HCl, and pass HS through it.	The Insoluble Portion. Dry the residue well, and mix it with NaO,CO_2+KCy, heat on charcoal support before the blow-pipe.
			Red Orange. Sb. (Observation *o*.)	Metallic Malleable Bead, looking like Silver. Sn. Dissolve the bead in HCl, and test as for Sn, with AuCl3, as described in the Dictionary.
	As.	Sb.	Sb.	Sn.

Cd. Treat, besides, the insoluble residue as in TABLE XXIV.

Brown Fumes and Incrustation.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

OBSERVATIONS ON TABLE XXIII.

a. In treating compounds with acids, fumes or gases are sometimes evolved with irresistible violence, even in the cold, so as to cause the contents of the flask, in which the experiment is taking place, to be squirted out, or to overflow. The operator should, therefore, pour the acid with caution at first, and by small quantities at a time, waiting until the effervescence has subsided before a fresh quantity of acid is added, heat being applied only at the end. If the compound is a metallic sulphuret, nitric acid, or aqua regia, will probably have been required, and then red fumes of nitrous acid are evolved, which indeed of themselves are generally indicative of the presence of a sulphur-compound. After boiling for some time the sulphur separates in spongy blackish or greyish flakes, which eventually agglomerate into yellow lumps of sulphur, and, in fact, the ebullition with NO_5 should be continued until either all (except silica) has dissolved, or until this separation of the sulphur in yellow lumps takes place, a portion (sometimes the whole) of which, however, is converted into sulphuric by the oxydizing action of the nitric acid or aqua regia employed to dissolve the compound, the metal of which is generally taken up by the acid long before the sulphur. A residue may also be left, which is due to the action of the nitric acid upon one of the constituents of the substance under examination. See Observation *c*, TABLE II—B. The agglomeration of the sulphur into yellow lumps frequently does not take place until the liquid has been nearly all boiled away; until then, it floats about in the shape of flakes of a blackish colour due to the admixture of the as yet undecomposed substance, which being enveloped, as it were, by the sulphur, is thus sheltered from the action of the acid: this more generally happens with the sulphurets of copper, nickel, cobalt, zinc, iron, manganese, and cadmium. The process of solution may, however, be expedited by transferring these greyish flakes, or spongy masses, of undecomposed sulphuret, to a small platinum capsule, and igniting them thereon, whereby the sulphur is volatilized, whilst the metallic oxyde remains behind as a fixed residue, which may be then dissolved in the proper acid, and added to the rest of the solution. (See also TABLE XXVII., Observation *b*.)

b. If pending the treatment of the compound with NO_5, violet fumes of iodine are evolved, it is a proof that an iodide is present.

c. If a sulphuret be present, in conjunction with a salt of lead, or of barytes, or of another base the sulphate of which is insoluble, it is evident that the treatment with NO_5 will produce an insoluble residue consisting of a sulphate of such bases, since the sulphur of the sulphuret, or a portion thereof, will have been converted into sulphuric acid by the action of the NO_5. We have already alluded several times to this circumstance.

Group 2 *to* 5.

d. The precipitate produced by HCl in metallic solutions is of course AgCl—Hg_2Cl, or PbCl; it may also be benzoic acid and boracic acid; but whilst the two first of these chlorides can be completely separated by HCl, the last cannot be thus entirely removed, because PbCl is not quite insoluble in water. PbO *may be present*, although HCl may have produced no precipitate or milkiness, since PbCl is to a certain extent soluble in water. Wherefore Pb will be present in the filtrate, and will subsequently be precipitated black by the stream of HS employed; and, moreover, as PbCl is more soluble in hot than in cold water, the solution treated by HCl should be cold, though even then, if it be too dilute, no PbCl will be precipitated.

If the solution contains both Ag and Pb, the addition of an excess of NH_3 to the above precipitate will, of course, dissolve the AgCl, and benzoic acid, but the filtrate, instead of being clear, will generally be milky, because a basic chloride of lead, which it contains, will be precipitated.

e. The addition of an acid to the solution of the compound, or its action upon the compound treated by it, may have produced a precipitate, or left an insoluble residue which may be due to the presence of benzoic, or of boracic acid. Benzoic acid may be at once recognized by adding an excess of ammonia to the precipitate, or insoluble residue, filtering, neutralizing *exactly* this ammoniacal solution with HCl, and adding to the liquor a solution of Fe_2Cl_3, which will then produce a bulky light brown precipitate.

As to boracic acid, the precipitate here alluded to cannot take place except in very concentrated solutions, and in the cold, or after the solution has cooled, and in that case its presence may be readily detected by adding alcohol to the precipitate, and inflaming the alcohol which will then burn with a characteristic yellowish green flame.

Group 6 *to* 25.

f. Dilution with water is necessary because it frequently happens that no precipitate is produced by HS until this has been done. Remember also that in certain solutions, such as those of SnO_2—AsO_3, and particularly AsO_5, a long time is required, and heat must be applied before precipitates make their appearance. Their formation is always hastened by heat, and a portion of the liquor should be mixed with SO_2 in order to convert AsO_5 into AsO_3, which is much more readily precipitated.

g. If the precipitate produced by HS is of a pure yellow colour, AsO_3—AsO_5—SnO_2—CdO, all or either of them may be present. (See Table XV. Observation *f*.)

If orange red, Sb alone is present, but it may possibly be mixed with AsO_3—AsO_5—SnO_2—CdO, all or either of them, for their sulphurets being yellow may not materially alter the hue of the orange-red sulphuret of antimony; in fact, a yellow colour of whatever shade always indicates the presence of one or more of these sulphurets.

If brown Sn is present, but Pb when in slight proportion instead of producing a black precipitate imparts a brown colour to the liquor; take care, therefore, not to mistake the one for the other. (See TABLE IV. Observation *m*.)

If black Au—Pt—Hg—Pb—Bi, all or either of them may be present, but SnO, or even SnO_2—AsO_3—AsO_5—CdO may be mixed with the precipitate, the yellow colour of their sulphurets being hidden by the darker hue of the others. (See Table IV. Observation *m*.)

The operator, however, by watching the action of the stream of HS on the solution, may become aware of the presence of the lighter coloured sulphurets, for these sulphurets are not generally produced with the same ease, and therefore do not appear at the same moment, so that a time may generally be observed when the production of the yellow colour takes place very visibly either before or after the darker sulphurets have made their appearance. The yellow colour begins generally on the sides of the disengagement tube, and sometimes long before any precipitate of that colour has actually taken place.

h. (Col. 8.) If CrO_3 was present, a large portion of the sulphur of the HS employed will have been oxydized, and the solution will then contain a more or less considerable quantity of SO_3. This circumstance should be carefully borne in mind when examining for acids. (See TABLE XV. Observation *e*.)

Group 9 to 18.

i. The quantity of NH_4S employed to dissolve the precipitated sulphurets must not be extravagantly large (a fault committed by all beginners not only with this, but with all reagents) because, on subsequently decomposing the solution with HCl., the quantity of sulphur deposited might conceal the presence of the sulphurets which had been taken up by the reagent. The sulphurets subsequently reprecipitated by HCl. being, of course, mixed with the sulphur resulting from the decomposition of the NH_4S employed are always, of course, lighter in colour than when first precipitated by HS.

j. (Col. 10.) In cases where AsO_5 is present, the precipitation of the AsS_5 will require a very long time indeed for its production, though the disengagement tube becomes coated with a film of yellow shortly after having caused the stream of HS to pass through it. The operator must not, therefore, be in a hurry to arrive at a negative conclusion, and he must, moreover, take care that the liquor is not too acid, else no precipitate will take place, even though much arsenic acid may be present. The precipitation of arsenic is considerably accelerated by converting it into AsO_3, which is done by adding SO_2 to the liquor before passing HS through it.

k. It is, moreover, essential thus to convert the AsO_5 into AsO_3 when zinc is present in the solution at the same time, for in that case the HS will precipitate it in the state of double sulphuret of zinc and of arsenic; whereas if SO_2 be first added, sulphuret of arsenic (AsS_3) only is precipitated, the whole of the zinc remaining in solution.

l. (Col. 9 to 10.) "*If there be no objection to it*," means if, for example, no SO_2 has been added to the original solution; for, in that case, AsO_5 would have been reduced to the state of AsO_3.

m. If AsO_3 and AsO_5 exist both at the same time in the solution, the neutralizing with NH_3, after the addition of AgO,NO_5 may be so managed that both acids will be detected, thus: The first precipitate which will appear after the cautious addition of NH_3 will be *yellow*, and will, therefore, indicate the presence of AsO_3, but by adding again with great care some NH_3, this yellow precipitate will disappear, and be replaced by one of a *light brown colour* (AgO, AsO_5), if AsO_5 be present.

Group 19 to 25.

n. The operator knows whether NH_4S has dissolved anything by filtering, and adding slight excess of HCl to the filtrate; if this produces a white precipitate, it is sulphur, which is merely due to the decomposition of the NH_4S by the HCl, and, therefore, nothing has been dissolved; but if a black or otherwise coloured precipitate is reproduced, it is the sulphuret which the NH_4S has dissolved, and which is reprecipitated.

o. (Col. 22.) We have already had occasion to remark that it was necessary to add a little HCl to the solution of the precipitate in tartaric acid, or to apply heat, for otherwise the current of HS would not produce the characteristic orange-red precipitate; if this precaution be neglected the liquor will only assume a dark red colour. Yet by long standing, even without the help of heat, or the addition of HCl, a precipitate of sulphuret of antimony eventually takes place.

p. (Col. 23.) See Observation *g*. on TABLE II.—B. To ascertain whether Sn existed in the compound as SnO, or SnO_2, treat the original solution as directed in TABLE XVI., Col. 5 to 6.

Group 24 to 25.

q. Do not be in a hurry to conclude that because a portion of the precipitate has not dissolved in the NH_4S employed, it is, therefore, insoluble therein, because SnS is always difficultly soluble in NH_4S, more particularly if not quite recently precipitated, and still more so if the hydro-sulphuret of ammonia used does not contain an excess of sulphur. (See TABLE XV., Observation *h*.)

r. (Col. 25.) It is evident that if enough HCl has been added to the solution at the beginning, it cannot now contain any Ag, since the salts of this metal are completely precipitated by HCl. In the same way if a subsalt of mercury was present, the solution cannot now contain any Hg, since the subsalts of that metal are also completely precipitated by HCl. But if the solution contained a persalt of mercury, the whole of the mercury was contained in the solution treated by HS, since the persalts of that metal are not precipitated at all by HCl, and hence the black precipitate insoluble in NH_4S may be due to the presence of mercury.

s. We have said already, TABLE XV. Observation *i*., that if the filtrate resulting from the digestion of the precipitate in NH_4S has a brown or blackish colour, it is probably due to the presence of Cu, and that, in that case, KS or NaS should be used instead of NH_4S. But if HgO is present at the same time (a fact which may be detected by the first impression of HS having caused the precipitate produced to assume first a white, then a yellow, then an orange, then a brownish red, and finally a black colour), if we repeat it, HgO be present at the same time, NH_4S must be used, notwithstanding the presence of Cu, since HgS is soluble in KS.

TABLE XXIV

Systematic Analysis of MIXED COMPOUNDS which are INSOLUBLE in WATER but which are SOLUBLE in ACIDS.

PRECIPITATES produced by HS, insoluble in NH_4S.

Wash the precipitate thoroughly, transfer a small portion of it to a small porcelain capsule, pour upon it some moderately dilute NO_5, and boil, stirring the mass all the while.

DISSOLVES completely.

(Except the sulphur resulting from the decomposition of the sulphuret, and which agglomerates into yellow lumps (Observations *a*, *b*, TABLE XVII.) Except also a white insoluble precipitate (PbO,SO_3) which may have been formed if Pb was present.)

Does NOT dissolve completely, or at all, a *black* residue being left.

Hg, which may be mixed with PbO,SO_3 produced by the action of the NO_5 on the S of the sulphuret.

Filter, and examine the filtrate for Cd, Cu— Pb—Ag — Pd Bi—Os, as described in the preceding Col. 2 to 10.

Boil the well washed insoluble precipitate with a small quantity of aqua regia, dilute with water, and allow it to cool.

Boil the rest of the precipitate with NO_5 in order to dissolve it, and if the precipitate *before* boiling with NO_5 was more or less.

Pure Yellow.

Observ. *f.* TABLE XV.

Cd.

Mix a portion of the yellow precipitate with NaO,CO_2 + KCy, and fuse before the blow-pipe on charcoal support.

Brown fumes, and brown incrustation but no metallic bead.

Cd.

Cd.

Dark Brown, or Black.

Cu—Cd—Hg—Pd—Pb—Bi—Os, &c. Filter in order to separate the agglomerated lumps of sulphur, or possibly the PbO,SO_3, resulting from the action of the NO_5 upon PbS (See TABLE XVII). Divide the filtrate into three portions.

1ST PORTION.

Add to this first portion an excess of NH_3.

2ND PORTION

Evaporate the excess of NO_5, and add excess of dilute SO_3.

White,

insoluble in acid, soluble in pure KO.

Confirm by moistening this white precipitate with NH_4S.

Black.

Pb.

(Obs. *b*.)

Pb.

3RD PORTION

Evaporate this third portion to dryness, dissolve the dry mass in water, containing a few drops of HCl, apply heat, pour the liquor into a long cylinder full of water.

White Precipitate, or Milkiness.

Bi.

Bi.

If a white insoluble sediment has formed while boiling the black sulphuret with NO_5 at the beginning, it is probably PbO,SO_3, collect therefore this white precipitate or sediment, and pour upon it a drop of NH_4S.

Black.

Pb.

Confirm by treating the sediment as described in TABLE XIII., Col. 4.

Pb.

If while boiling the precipitate in NO_5, as directed at the beginning of this TABLE, a peculiar odour resembling that of chloride of sulphur, exciting cough, is observed, it is due to the presence of Os.

As soon, therefore, as this is observed, close the flask with a cork provided with a tube so as to condense the vapours of OsO_4, add to these condensed fumes a solution of a sulphite.

Purple Blue.

Os.

Os.

NO PRECIPITATE, and the liquor is Blue, or Colourless.

Precipitate.

Pb—Bi—OS, but possibly also Cd--Cu--Hg--Pd. Filter, and examine the filtrate as in Col. 2 to 5. The precipitate which may consist of Pb—Bi—Os, all or either of them may be kept, but these substances will be detected in the second and third portion, and also in Col. 9 and 10.

Pb Bi Os.

White insoluble residue.

Pour a drop of NH_4S on the white residue,

Black.

Pb.

Confirm by treating the insoluble residue as directed, TABLE XIII., Col. 4.

Pb.

Dissolves.

Hg.

Add to the solution as much NH_3 as is necessary, nearly to neutralize it; put then a few drops upon a clean piece of copper, wipe off, and rub the part with a piece of paper.

Silver stain.

Confirm by testing, as described in TABLE XVII., Col. 11.

Hg.

Acidify the clear ammoniacal liquor with $\overline{A}$,HO, and then add thereto some K_2Cfy

Crimson.

Cu.

If the ammoniacal liquor was blue, Cu is certainly present.

Cu.

Cu.

To a portion of the ammoniacal filtrate which may be blue owing to the presence of Cu, add excess of NH_4O,CO_2 boil for a quarter of an hour, leave the whole at rest for a while.

White.

Cd.

Confirm as directed, TABLE XVII., Col. 3, and Observation *e*, thereon.

Cd.

Cd.

To another portion of the ammoniacal solution, which may be blue from the presence of Cu, add an excess of HCl.

White, Curdy.

insoluble in acids; immediately soluble in excess of NH_3.

Ag.

(See TABLE XVII., Observ. *f*.)

Ag.

To another portion of the ammoniacal liquor which may be blue from the presence of Cu, add as much HCl as is necessary *exactly* to neutralize it, filter if necessary, and add HgCy or KCy to it.

Yellowish White

soluble in great excess of HCl.

Pd.

(Obser. *a*.)

Pd.

TREATMENT of Solutions NOT precipitated by HS, or of the liquors filtered from Precipitates by HS, and alluded to in TABLE XXIII., Col. 6, 7, 8.

Take a small portion of the liquor under examination, add an excess of sal ammoniac to it, and likewise as much NH_3 as is necessary to render it alkaline (Observation *c*), and whether or not a precipitate is produced, add NH_4S.

O.

Absence of Fe—Ni—Co—Mn—Cr—Zn—Al, Phosphates, arseniates, oxalates of earths.

Go to TABLE XXV.

Black, Grey, or Otherwise Coloured.

Fe—Co—Ni—Cr— Mn — Zn —Al. Also phosphates, oxalates, arseniates, and perhaps borates and fluorides of earths. (See TABLE XVIII., Observations *d*, *e*, *f*.)

If the precipitate was BLACK or BLACKISH, the presence of Fe—Co—Ni or either of them is certain. (See the Observations on TABLE XVIII.)

Treat the rest of the liquor exactly as the small portion operated upon, and separate the precipitate by filtering. Examine whether the filtrate contains anything, and if so, keep it for further examination, as in TABLE XXV. Wash the precipitate well with water containing a little NH_4S, and whilst it is on the filter and moist, pour upon it a certain quantity of HCl diluted with about five times its bulk of water.

Does NOT dissolve completely, or at all.

but a residue is left, which is

Black.

Presence of CO—Ni, or either of them.

Fuse at once a portion of this residue with borax on the hook of a platinum wire before the blow-pipe: if a BLUE bead is obtained, cobalt is present. But as Ni may also be present at the same time, wash the whole residue down into the HCl liquor, which was filtered from that residue, add NO_5, and boil, in order to dissolve it all.

Dissolves completely.

Presence of Fe—Cr—Mn—Zn—Al, and possibly phosphates, oxalates, arseniates, perhaps also borates of earths; perhaps also small quantities of Co and Ni, the sulphurets of these two metals not being quite insoluble in HCl.

To the solution of the precipitate in HCl add NO_5, and boil, in order to convert the FeO, which may be present, into Fe_2O_3.

White.

Presence of Zn—Al, or either of them, also phosphates, oxalates, borates, fluorides of earths. Ni—Co—Fe, may also be present in small quantities, in which case the precipitate, instead of being pure white, has a more or less greyish tinge.

Treat the rest of the liquor exactly as the small portion operated upon, that is, by NH_4Cl + NH_3 + NH_4S, as long as a precipitate is produced. Separate the precipitate, and if the filtrate contains anything, keep it for further examination, as in TAB. XXV. Wash the precipitate thoroughly with water, containing a little NH_4S, and boil with HCl, until all odour of HS has disappeared; separate the sulphur by filtering.

(If a very small black residue, insoluble in HCl, is left, it is generally due to traces of Co or Ni.)

Add NO_5 to the solution, and boil until all is dissolved, except the sulphur, which may be at once removed.

Take a small portion of this acid solution, add thereto a few drops of CaCl, and then as much NH_3 as is necessary *exactly*, but not quite to neutralize it, and whether or not a precipitate is produced, add an excess of $\overline{A}$,HO.

NO PRECIPITATE is produced, or if one is formed, it is REDISSOLVED by the $\overline{A}$,HO.

Neutralize the $\overline{A}$,HO in the liquor (which may be filtered if necessary) with KO, add thereto a drop of Fe_2Cl_3. If this produces a yellowish white precipitate, phosphates of earths are present. The solution may contain borates and arseniates besides. These will be detected below.

A PRECIPITATE is formed INSOLUBLE in excess of $\overline{A}$,HO.

Presence of oxalates of earths (probably). If the quantity is small 12 hours may be required for the precipitate to appear. Filter, and treat the filtrate as if the precipitate had completely dissolved.

Whether or not a precipitate has been produced when tested for phosphates and oxalates as just said, add to the rest of the solution of the precipitate in NO5, a large excess of caustic KO, and boil for about 10 minutes, *dilute with water*, and filter. (Obs. *d*.)

The FILTRATE.

Divide into Four Portions.

1

To the clear strongly alkaline solution add NH_4S,

White.

(Obser. *e*.) Zn.

See Obs. *i*. on TABLE XVIII., Confirm by heating a small portion of the precipitate previously moistened with CoO,NO_5 before the blow-pipe.

Emerald Green.

Zn.

2

Acidify the strongly alkaline solution with HCl, add excess of NH_3, and shake vigorously,

White.

Al. Confirm by moistening a portion of the precipitate with CoO,NO_5, and heating before the blow-pipe,

Blue.

Al.

3

Acidify the strongly alkaline filtrate with NO_5, add AgO,NO_5, filter if necessary, add a drop or two more of AgO,NO_5 to the filtrate, and neutralize *exactly* with NH_3

Light Brown.

AsO_5.

(Obser. *f*.)

AsO_5.

4

Acidify the strongly alkaline filtrate, evaporate nearly to dryness, add concentrated SO_3HO to the dry residue, then some alcohol or naphtha, and inflame.

Yellowish Green flame.

BO_3.

(See TAB. XVIII., Obser. *j*.)

BO_3.

THE PRECIPITATE.

Wash the precipitate thoroughly with water. If the original solution was colourless, probable absence of Co and Cr. (See Obs. on TAB. XVIII., Col 7 to 12.

Mix a portion of the precipitate with NaO,CO_2, + a little KO,NO_5, and heat strongly on platinum foil with the blow-pipe.

Turquoy Blue.

Mn. Confirm by boiling a portion of the precipitate with NO_5 + red lead.

Purple colour.

Mn.

(Obs. *g*, *h*.) Mn.

Fuse another portion of the precipitate with borax before the blow-pipe.

Blue bead.

Co.

(Observ. *g*, *h*.)

Co.

Triturate a small portion of the precipitate with NaO,CO_2 + 3 parts of KO,NO_5 and proceed exactly as described in TABLE XVIII., Col. 9.

Cr.

Cr.

Dissolve about half of what is left of the precipitate in NO_5, and divide into two portions.

1

Neutralize as nearly as possible, but not quite, with NH_3 and to the clear filtrate add a drop of $FeCl_3$ + excess of $KO,\overline{A}$.

Yellowish White.

PhO_5.

(See TAB. XVIII. Obser. *l*.)

PhO_5.

2

Evapo to a very small bulk and proceed exactly as described in TABLE XVIII. Col. 9, 10, 11.

(Obser. *i*.)

$\overline{HFl}$.

$\overline{O}$,HO.

HFl

$\overline{O}$,HO.

Dissolve the rest of the precipitate in a small quantity of HCl, and divide into two portions.

1

Add solution of KO until it has only a very slight acid reaction on paper, stirring the whole at the same time, and using only a dilute solution of KO towards the end, and heat to boiling. If a precipitate takes place it is iron. (Obs. *j*.) Filter, dissolve the precipitate on the filter with HCl, and test with Cfy_2K.

Blue.

Fe.

Whether Fe existed in the original solution as FeO, or Fe_2O_3, is detected, as in TABLE XVIII., Col. 13, 14, and Observ. *n*.

2

Add moreHCl and an excess of KCy to strong alkaline reaction, boil, add SO_3HO to the filtrate.

Light Yellowish Green.

Ni.

Ni.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

OBSERVATIONS ON TABLE XXIV.

Group 1 *to* 12.

*a.**(Col. 5.) If, however, the liquor contains silver or lead, or both, these metals should be first eliminated, by adding to the liquor an excess of HCl, or of dilute SO_3HO, by which the Ag or Pb will be precipitated, or both HCl and dilute SO_3HO, if both these metals are present. The liquid is then filtered, to separate the precipitates, the filtrate is neutralized exactly with NaO,CO_2, and if the addition of HgCy produces then a yellowish-white gelatinous precipitate, it is palladium. This yellowish-white precipitate becomes completely white by standing. (See also TABLE XVII., Observations *c*, *g*.)

b. (Col. 7.) It may happen that although the compound contains lead, yet no precipitate will be obtained by treating the second portion with dilute SO_3. This will be the case if the quantity of lead is small, or if enough sulphuric acid has been produced by the action of the NO_5 employed at the beginning to dissolve the sulphuret insoluble in NH_4S, for in that case the whole of the lead will have been converted into an insoluble white powder, which in fact is sulphate of lead. The operator must not, therefore, omit to examine that insoluble residue as described in Col. 9.

Group 14 *to* 24.

c. If alumina, oxyde of chromium, of iron, and of cobalt, are present, or if the solution contains phosphates, arseniates, oxalates, or even borates of earths, this addition of NH_3 will be sure to produce a precipitate; the latter, however (borates of earths), are thus precipitated only when a sufficient quantity of sal-ammoniac has not been employed. (See TABLE XVIII., Observations *a*, *b*, *c*, especially *l*.)

d. It is necessary to dilute with water, because otherwise the causticity of the liquor will burst the filter.

Group 14 *to* 17. †

e. (Col. 14.) We have already had occasion to remark that the smallest quantity of iron is sufficient to impart a black tinge to this precipitate; but if the liquor is clear, colourless, and strongly alkaline, the precipitate produced by NH_4S is ZnS.

f. (Col. 16.) If the solution to be tested for arsenic contains HCl, the addition of AgO,NO_5, will, of course, produce a white precipitate. In that case, an excess of AgO,NO_5, should be poured into the liquor, and heated so as to agglomerate the precipitate; the whole is then thrown upon a filter, and the filtrate to which another drop of AgO,NO_5 should be added to make sure that all the chlorine is removed, and that there is an excess of AgO,NO_5, is then tested for AsO_5, as directed.

Group 18 *to* 22.

g. (Col. 18, 19.) If the solution contains Mn, as well as Co, the blue colour of the bead, which is characteristic of the presence of Co, may be so deeply altered as not to be recognizable; or it even may be completely obliterated by the amethyst colour which Mn imparts to borax when similarly treated. Cobalt, however, will have been already detected, if present, when treating the black sulphuret with HCl, nearly at the beginning of the second division of the present Table.

h. Moreover, if copper was present, it may happen that the liquor filtered from the black precipitate of sulphuret of copper produced by HS, may contain copper, if the operator has not taken care to wash that sulphuret with water containing a little HS, for in that case, a portion of the sulphuret of copper may have been converted, by the oxygen of the air, into sulphate of copper, which will, of course, have dissolved, and being therefore present in the filtered liquid, will now be precipitated by the caustic KO employed; the consequence will be, that on fusing the precipitate with borax, a bead of a pale blue colour may be obtained, which may simulate the presence of cobalt, whilst in reality it may be all due to copper. The blue colour of the bead by cobalt is, however, much finer and more intense, and moreover, it is blue in *both flames* of the blow-pipe, which is not the case with copper.

i. (Col. 22.) Instead of a solution of this precipitate, the original solution may be evaporated to a small bulk, and then tested for $\bar{O},HO$.

Group 23 *to* 24.

j. (Col. 23.) This method of separating iron from manganese, cobalt, and nickel, is grounded upon this, that in neutral or slightly basic persalts of iron, the peroxyde of the metal is precipitated from such solutions merely by boiling, whilst the manganese, cobalt, and nickel remain in solution. The slight precipitate which sometimes begins to appear in the cold, when the solution is nearly neutralized, is peroxyde of iron. In order not to go beyond the neutralizing point, the operator is recommended to use a dilute solution of potash towards the end; but should he, by accident, have added too much alkali, a sufficient quantity of acid should be added to restore the slightly acid reaction, after stirring the whole well. The quantity of acid should not, however, be quite enough to redissolve all the precipitate, a few flakes of which may be observed floating about, and which consist altogether of peroxyde of iron. The whole of the iron is precipitated the moment the solution is made to boil, and therefore the boiling need not be continued

* *a.* (Col. 1.) The confirmatory test alluded to consists in mixing intimately the yellow sulphuret which has proved insoluble in NH_4S with about four times its weight of KCy, transferring the mixture to a small test tube of German glass, and exposing it therein to a good red heat by means of an argand spirit lamp, the tube being held in an almost horizontal position. A metallic ring will then be observed at about one inch and a half or two inches from the heated point, and below this ring the operator will remark an incrustation of a yellow colour, becoming brown, and sometimes black, as it gradually descends towards the part of the tube which has been heated the most. The mirror is metallic cadmium; the bands consist of anhydrous oxyde of cadmium. See TABLE XVII., Col. 1.

† Read with great care the Observations *d*—*m* on TABLE XVIII., which entirely apply here.

Systematic Analysis of MIXED COMPOUNDS which are INSOLUBLE in WATER, but which are SOLUBLE in ACIDS.

Solutions not precipitated by HS, nor by NH_4S.

To a portion of the solution in which HS and then NH_4S failed to produce a precipitate, or to the liquor which was filtered from the precipitates which these reagents may have produced, and alluded to in TABLE XXIV., Col. 13, add HCl to supersaturation, and boil until all odour of HS has completely vanished; filter, if necessary, and if the clear liquor or filtrate does not contain any, or enough sal-ammoniac, add some to it, then pour into it a slight excess of NH_3, and an excess of NH_4O,CO_2, apply heat to the mixture, so that it may very gently simmer for a while.

NO Precipitate.

Absence of Ba—St—Ca, but possible presence of KO—NH_3—MgO. (Observation *a*.)

Examine whether a residue is left, by evaporating a few drops on a platinum foil, and if one is left, test a portion of the liquor with dilute SO_3, or a soluble sulphate, and another portion with $NH_4O,\overline{O}$. If no precipitate or turbidness is produced, it is as it should be; but if either of these reagents produce a precipitate or turbidness, it is a sign that the operator has not used enough NH_4O,CO_2, and that the liquor still contains some earth which must be removed, before testing for magnesia, by boiling the whole liquor again with a fresh quantity of NH_4O,CO_2; filter, and then test the filtrate, by evaporating again a few drops of it on platinum foil. If a residue is then left, go to Col. 6, and following.

1

A Precipitate.

Presence of Ba—St—Ca, all, or either of them. Treat the whole as the sample. Filter, and treat the filtrate as in Col. 1, that is, as if no precipitate had been produced.

Dissolve the precipitate in $\overline{A}$,HO—dilute a portion of it with a little water, and test with $KO,2CrO_3$. (See Observation *c*, TABLE X.)

Yellow.

Presence of Ba; but St and Ca may also be present at the same time. Treat the rest of the solution of the precipitate with $KO,2CrO_3$ as long as a precipitate is produced, filter, and treat the filtrate as in Col. 3, 4, 5.

Confirm by testing a portion of the concentrated original solution with $HFl,SiFl_2$, and shake well.

White Crystalline.

Ba.

(See Observation *f*, TABLE XIX., and *e*, TABLE VI.)

Ba.

2

NO Precipitate.

Evaporate the whole of the liquor to dryness, redissolve the residue in water, and if a white powder refuses to dissolve, add a few drops of dilute HCl, evaporate to dryness, dissolve now the residue in water (Observation *b*), and divide into two portions.

1ST PORTION.

Add an aqueous solution of CaO,SO_3 to a portion of this liquor, shake violently, and leave the whole at rest for some time.

White.

St.

Confirm by evaporating to dryness, add to the dry residue a few drops of HCl, and then some alcohol, ignite, stirring the mixture all the while.

Carmine Red Flame.

(See Observation *g*, on TABLE XIX.)

St.

3

NO Precipitate.

Possible presence of Ca.

Supersaturate the rest of the liquor with NH_3, and then add some $\overline{O}$,HO. (See Observation *d*, on TABLE X.)

White.

Soluble in excess of NO_5, and of HCl.

Ca.

(See TABLE VI., Observations *j*, *k*, and TABLE X., Observation *d*.

Ca.

4

2ND PORTION.

Add to this portion some KO,SO_3, apply a gentle heat and leave it at rest for some time (if a precipitate is produced, remove it by filtering, it is StO,SO_3), and to the clear liquor or filtrate add an excess of NH_3, and then $\overline{O}$,HO.

White.

Soluble in excess of NO_5, or of HCl.

Ca.

(See TABLE VI., Observations *j*, *k*, and TABLE X., Observation *d*.

Ca.

5

Solutions not precipitated by HS, nor by NH_4S, nor by NH_4O,CO_2.

Evaporate to dryness a portion of the liquor filtered from the precipitates produced by the above reagents, or a portion of the original solution in which the said reagents altogether failed to produce a precipitate, ignite the dry mass until white fumes are no longer evolved, in order to expel all ammoniacal salts. Dissolve the ignited mass in the smallest possible quantity of water, or if a white powder be left which refuses to dissolve, add a few drops of HCl (if it does not dissolve then, it is probably silica), evaporate to dryness, redissolve in water, and divide the liquor into two portions. (See **Observation** *a*, on TABLE XX.)

1ST PORTION.

Add $\overline{(2NaO)\ HO,PhO_5}$, and shake vigorously. (See Observation *b*. on TABLE XX.)

White.

MgO.

Submit this precipitate to the blow-pipe and test with CoO,NO_5.

Mass of a faint Pink colour.

(See TABLE I.—B., Col. 9.)

MgO.

6

2ND PORTION.

Add some alcohol, heat, and inflame.

Purple flame.

KO.

To another portion highly concentrated, add solution of $PtCl_2$, and a little alcohol.

Yellow.

KO.

(Observation *c*.)

7

EXAMINATION for Ammonia

Take a portion of the original solution to which, of course, no NH_3 has been added, pour into it a concentrated solution of KO, and if a smell of ammonia is not immediately developed, apply heat.

Pungent odour of NH_3.

Hold a glass rod moistened with strong but not fuming HCl.

White fumes.

The vapour evolved, especially by heating, restores the blue colour of red litmus paper.

NH_3.

(Observation *c*.)

8

OBSERVATIONS ON TABLE XXV.

Group 1.

a. (Col. 1.) Be not in a hurry to conclude that Ba—St,—Ca, are absent, because a precipitate does not immediately appear after treatment with NH_4 O, CO_2, for when only small quantities of these substances are contained in the solution *a few hours* will be required for the precipitate to be formed.

Group 3 to 5.

(Col. 3.) It may happen that even after adding a few drops of HCl a white residue will be left which refuses to dissolve. This is the case if silica be present, but silica is always easily identified by its grittiness and by the blow-pipe.

c. All the salts of potash, of soda, and of ammonia being soluble in water cannot exist in the solutions now under consideration, yet perchlorate of potash and perchlorate of ammonia being almost insoluble in water, and bitratrate of potash being only sparingly soluble in that menstrum, we have included these two bases in the present Table.

TABLE XXVI.—A.

Systematic Analysis of MIXED COMPOUNDS which are INSOLUBLE IN WATER, but which are SOLUBLE IN ACIDS, and which contain INORGANIC ACIDS ONLY.

Whether Organic Acids are present or not will have been determined in the preliminary examination, TABLES I.—A., I.—C., I.—D., I.—E. (Observation *a*.)

Take a portion of the well-pulverized compound, treat it first with cold HCl, diluted with its own bulk of water, and then boil it with that same acid, as directed in TABLE I.—E., filter if necessary.

EFFERVESCENCE or NOT. With or without Odour. (Observation *b*.)

NO ODOUR.

But effervescence. (Observ. *e*, TABLE I.—E.) CO_2, and, therefore, CARBONATES are present. Confirm by passing the gas evolved through lime-water.

White.

CO_2. (Observation *g*, TABLE I.—E.)

CO_2.

ODOUR of SO_2.

Presence of Sulphites and Hyposulphites, but, possibly, also of Carbonates.

Pass the gas through lime-water, as in Col. 1.

White.

CO_2.

CO_2.

Boil the compound for some time with KO,CO_2, or NaO,CO_2, filter, and to the filtrate add SO_3HO.

Odour of SO_2.

Confirm by the usual tests. (See Dictionary.)

SO_2.

ODOUR of HS.

Sulphurets, but, possibly, *Carbonates* also, and, possibly, also presence of a *Sulphite*. (Observ. *g* to *i*, TABLE I.—E.)

Pass the gas evolved through lime-water, as in Col. 1.

White.

CO_2.

CO_2.

Suspend a strip of paper, moistened with basic acetate of lead, into the gas evolved. It turns

Brown or Black.

HS.

S.

ODOUR of Cl.

Presence of certain Peroxydes, Bromates, Iodates, &c. See TABLE I.—E., Col. 6. But, possibly, also Sulphurets, Carbonates, Sulphites, &c. (Observations *g* to *i*, TABLE I.—E.)

Evaporate the clear solution in HCl *to perfect dryness*, drench the dry residue with concentrated HCl, and leave the whole to digest for about a quarter of an hour, boil with water, and filter.

Insoluble White Gritty Powder.

SiO_3. Confirm by the usual tests for SiO_3, which see in Dictionary. The filtrate may be treated as in the following Columns.

SiO_3.

Take a portion of the well pulverized compound, add thereto some concentrated SO_3HO + some alcohol, or wood naphtha, and inflame.

Greenish Yellow Flame.

(Observation *c*.) BO_3.

BO_3.

Take another portion of the solution in HCl and treat with FeO,SO_3 + SO_3, or with copper filings + SO_3, as directed in TABLE XXI., Col. 21. or as in the tests for NO_5. If the first produces

Brown Tinge,

and the second,

Ruddy Fumes.

NO_5. (Observation *d*.)

NO_5.

Through the rest of the liquor in HCl (or, better still, through that which was evaporated to dryness, and redissolved when testing for SiO_3, Col. 7, and which was accordingly filtered from the SiO_3, if any was present) pass a stream of HS to supersaturation (the liquor should not be too acid, or, if so, evaporate the excess—it should, moreover, be suitably diluted with water); filter, if necessary. Boil the filtrate until all odour of HS has disappeared, add, then, to the filtrate an excess of NH_3; filter, if necessary, and add to the filtrate NH_4S, as long as a precipitate is thereby produced, filter again, if necessary. Neutralize exactly with HCl or with NH_3, as the case may be (see the Observations on TABLE XXI.), and to the clear liquor add solution of BaCl. (Observation *e*.)

NO Precipitate.

Go to TABLE XXVI.—B.

A Precipitate is produced.

Possible presence of BO_3—SO_3—IO_5—(AsO_3—AsO_5)—PhO_5—PhO_3—HFl—CrO_3. (See Obs. on TABLE XXI., Cols. 2 to 9.)

Dry a portion of the precipitate mix it with pulverized KO,SO_3 (about twice its bulk), and, putting it into a glass test-tube, apply the heat of a spirit-lamp thereto.

Violet Fumes.

IO_5.

IO_5.

Digest the whole of the precipitate in HCl.

Does NOT Dissolve Completely, or at all.

SO_3. (Observ. *e*.) Filter, and treat the filtrate as if the precipitate had been completely dissolved. Fuse a portion of the insoluble residue with NaO,CO_2, on a charcoal support, with the blow-pipe remove the fused mass, or the place on which it rested, put it on a clean piece of silver, and moisten it thereon with a few drops of dilute HCl.

Odour of HS.

Brown Stain.

SO_3.

SO_3.

Dissolves Completely.

To the clear acid liquor or filtrate add NH_3, until it acquires a very slight alkaline reaction, add CaCl, and boil. (See Observations on that part in TABLE XXI., Cols. 4 to 9.)

White.

Presence of BO_3—PhO_5—PhO_3—$\overline{O}$,HO—HFl.—Digest the Precipitate in $\overline{A}$,HO.

Does NOT Dissolve Completely, or at all.

$\overline{O}$,HO HFl. Filter, and treat the filtrate as if the precipitate had completely dissolved. Treat the insoluble portion with HCl.

Does NOT Dissolve.

Filter, and treat the filtrate as if it had dissolved. HFl. Confirm by treating the original compound, or this insoluble residue, by concentrated SO_3, in a platinum crucible, and a piece of glass coated with wax. (See test for HFl, in Dictionary.)

Corrosion.

HFl.

Dissolves.

$\overline{O}$,HO. Add excess of NH_3 to this solution.

White.

Collect and dry this precipitate (or a portion of original compound), treat it in test-tube with MnO_2 + SO_3HO, apply heat, and inflame. — (See tests for $\overline{O}$,HO, in Dictionary.)

Blue Flame.

$\overline{O}$,HO.

Dissolves Completely.

BO_3—PhO_5—PhO_3—add excess of NH_3.

O.

Certain absence of PhO_5. Treat a portion of the original compound with concentrated SO_3HO + alcohol, and inflame.

Yellowish Green Flame.

BO_3. (Observation *c*.)

BO_3.

Precipitate. (See Observations on this part in TABLE XXI.)

Mix a small portion of the precipitate (or evaporate a portion of the filtrate from this precipitate nearly to dryness, and mix the residue) with a little concentrated SO_3HO + alcohol, and inflame.

Yellowish Green Flame.

BO_3. (Observ. *c*.)

BO_3.

Redissolve the precipitate in $\overline{A}$,HO, and divide into two portions.

First portion. Take a little of that first portion and treat it with $KO,\overline{A}$—Fe_2Cl_3—$\overline{T}$,2HO—NH_3 and MgO,SO_3, precisely as directed in TABLE XXI., Col. 8.

White.

PhO_5. (See TABLE XXII.—A, Observation *n*.)

PhO_5.

Second portion. To a little of that portion, nearly neutralized by NH_3, add AgO,NO_5.

Brown.

By boiling,

Black.

PhO_3.

PhO_3.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

OBSERVATIONS ON TABLE XXVI.—A.

a. The preliminary examination of the compound, according to TABLES I.—A., I.—C., I.—D., I.—E., will, besides, have shown already the presence of CO_2—AsO_3—AsO_5—CrO_3—HCy.

Group 1 *to* 6.

b. We have already remarked in the Observations on TABLE I.—E., Observations *f*, *g*, *h*, that sulphurous acid and sulphuretted hydrogen decomposed each other, and that, consequently, these two gases could not be evolved simultaneously. Of course, if one of them is in excess, its characteristic odour will become apparent. If, therefore, the compound contains a sulphite and a sulphuret, both insoluble or sparingly soluble, in water, the operator should boil the compound with KO,CO_2, or NaO,CO_2, whereby the metallic sulphite will be converted into a sulphite of alkali, to the solution of which SO_3HO being added, will disengage therefrom sulphurous acid gas, immediately recognizable by its odour of burning sulphur.

c. (Col. 8.) If chlorides are present at the same time, the addition of concentrated SO_3HO will produce an intumescence, which had better be allowed to subside before alcohol is added and inflamed; even with this precaution, the alcohol often burns with a greenish blue flame, which by a careless observer may be mistaken for that which is due to the presence of boracic acid, the flame of which, however, is of a different hue. The operator is advised in this, as in all other doubtful cases, to try the effect of the reagent with substances of a known composition, and to compare the results.

d. (Col. 9.) It is evident that if a nitrate is present, it must be one of lead (basic), since all other nitrates are soluble in water, and that of mercury and of bismuth are decomposed by it.

Group 12 *to* 18.

e. (Col. 12). If the liquor contained nitric acid, and if the solution now tested be one from which bases have been precipitated by NH_4S, the act of boiling the filtrate from the precipitated sulphurets will have produced a certain quantity of sulphuric acid, and the white precipitate now produced by BaCl may, of course, be nothing else than BaO,SO_3. If this happens, it will be necessary to test the original liquor for sulphuric acid, in order to make sure that that acid was really present and is not an accidental product.

On the other hand, the solution being neutral, the precipitate produced by BaCl may pass through the filter, so that it may be impossible to obtain a clear filtrate; in that case, the turbid liquor should be boiled for some time in order to agglomerate the precipitate, after which it will filter clear. (See Observ. *s*, TABLE VII., and *g*, TABLE XXI.)

TABLE XXVI.—B.

Systematic Analysis of MIXED COMPOUNDS which are INSOLUBLE in WATER, but which are SOLUBLE in ACIDS, and which contain INORGANIC ACIDS ONLY.

Take a portion of the well pulverized compound, treat it with moderately strong NO_5, at first in the cold, and then by boiling for a sufficient length of time to dissolve it, exactly, in fact, as was already directed in TABLES I.—C., E., and II.—B. (see Observations on TABLE XVI.—A.), dilute with a suitable quantity of water after having evaporated the excess of acid; filter if necessary. (Observation *a*.)

NO GAS, NO FUMES evolved. — Go to Col. 6, and following.

Gas or Fumes evolved, with or without effervescence. — Carbonates—Sulphurets—Iodides, certain metals. (Obs. on TABLE XXVI.—A.)

NO Odour or Colour.	Reddish Brown acid vapours.	Violet fumes.
CO_2. Presence of Carbonates. Confirm by passing the gas evolved through lime-water, as in Col. 1., TABLE XXVI.—A.	Presence of sulphurets, certain metals. (Observ. *a*.) Possibly also carbonates. The presence of the latter are detected by lime water, as already described in TABLE XXVI.—A. If by protracted boiling with NO_5.	Presence of Iodides. Confirm by placing a piece of paper moistened with starch paste in the tube. The paper turns
	Yellow lumps	**Blue.**
	are obtained, or if whilst the liquor which resulted from treatment with HCl, and in which no SO_3 was detected by operating, as in TABLE XXVI.—A, the present solution in NO_5 on being now tested with BaO,NO_5. yields a	HI. (Observ. *b*.)
	White Precipitate.	
	insoluble in water, (Observ. *s*. TABLE VII.) and in acids, then the compound contained a sulphuret	
CO_2.	S.	HI.

NO PRECIPITATE. — Through the rest of the liquor in NO_5 (or through the liquor which has been filtered from the precipitates produced by HS—by NH_3 and NH_4S, or in which these reagents failed to produce a precipitate) pass a stream of HS to supersaturation (the liquor should not be too acid, and should be suitably diluted with water); filter if necessary. Boil until all odour of HS has disappeared; add to the filtrate an excess of NH_3; filter again if necessary. To the clear liquor or filtrate add NH_4S as long as a precipitate is produced; filter again if necessary, supersaturate with NO_5, and boil until all odour of HS has disappeared; filter if necessary, *neutralize exactly*, and add AgO,NO_5. See Obs. *a*.

Therefore absence of HCl —BO_3—PhO_5 —PhO_3—CrO_3 —SiO_3—$\overline{O}$,HO —$\overline{T}$,2HO— $\overline{Ci}$,3HO, &c.

Examine according to Col. 16.

A PRECIPITATE. (See in TABLE XXI. the Observations from *m* to *s*.)

Possible presence of PhO_5—PhO_3—BO_3 (in concentrated solutions)—$\overline{O}$,HO—IO_5—AsO_5—AsO_3, all of which will have been already found in TABLE XXVI.—A.
Possible presence also of HI—$HCyS_2$—BrO_5—HCl—HCy—HBr, or the salts of these acids, which are the principal objects of this Table.
Digest the precipitate in dilute NO_5.

Does NOT Dissolve completely, or at all.

HI—$HCyS_2$—IO_5—BrO_5—HCl—HCy—HBr.—(Filter; the filtrate may contain all the acids in Col. 5.) Wash the insoluble precipitate with water, and heat it with a pretty large excess of NH_3.

Does NOT Dissolve completely or at all.

(See Observations on Col. 11, 12, TABLE XXI.) Filter, and treat the filtrate as if the precipitate had completely dissolved.
Presence of an *iodide*, or of a *sulphocyanide*.

To a portion of the original solution add NO_5 and an aqueous solution of starch in the cold.

Blue Colour.

Iodide, HI.

HI will already have been detected, Col. 4, and in the preliminary examination. TABLE I.—C.

HI.

To another portion of the original solution add Fe_2Cl_3.

Blood Red Colour.

Sulphocyanide. $HCyS_2$. (Obs. ...)

$HCyS_2$.

Dissolves completely.

HCl—HBr—HCy—BrO_5—IO_5. To this solution of the precipitate in NH_3 add an excess of NO_5.

Re-precipitated.

Dry a portion of the precipitate, mix it well with $KO,2SO_3$, put the whole into a glass tube and apply heat, as in TABLE I.—A. Group 3 to 6.

Purple fumes,

Iodate. IO_5.

IO_5.

Dry another portion of the precipitate, and test it with cold concentrated SO_3,HO.

Hyacinth. Red fumes.

Plunge in the tube a red hot splinter of wood,

Kindled.

Treat the mass in the tube with ether (about ten times its bulk), shake, and operate exactly as in TABLE VII. Col. 22, 23.

Bromate. BrO_5.

BrO_5.

If NO Br nor I have been found.

Wash the precipitate, transfer it whilst still moist to a porcelain crucible, dry it, and ignite it in a small test tube. (See Observations on Col. 15, 16, TABLE XXI.), boil the residue with NO_5, filter.

The insoluble residue.	The FILTRATE.
It is AgCl. Treat it as directed in TABLE XIII. Col. 3.	Add thereto some HCl.
HCl.	**White.**
	Presence of a *cyanide*. Confirm by testing the original solution with FeO,SO_3 + KO + HCl; also by NH_4S_5, as described in tests for HCy.
HCl.	HCy.

If Br or I have been found.

Test the original solution with FeO,SO_3 + a few drops of Fe_2Cl_3 + an excess of KO + a slight excess of HCl.

Prussian Blue.

HCy. Confirm by testing with NH_3S_5, as described in the tests for HCy (which see).

Blood Red Colour.

HCy.

HCy.

To another portion of the original liquor add an excess of a solution of 1 part of crystallized CuO,SO_3 + $2\frac{1}{4}$ parts of crystallized FeO,SO_3.

Dingy White. (Cu_2I.)

Having thus removed the I, remove the excess of FeO,SO_3 + CuO,SO_3 by adding a solution of KO, filter, evaporate the filtrate to dryness, mix with $KO,2CrO_3$, pulverize the mass, and introduce it into a glass test tube, pour upon the mass some concentrated SO_3,HO, and proceed as directed in TABLE I.—C., Col, 27, 28.

Brown fumes.	Blood Red liquid.
HBr.	Presence of HCl.
HBr.	HCl.

Dissolves completely.

Possible presence of PhO_5— $\overline{O}$,HO— BO_3— AsO_5— AsO_3— SiO_3— CrO_3.

All, or either of them.

All these will have been precipitated and identified before.—SiO_3 will have been discovered in the preceding Table, Col. 7,

If in the course of this investigation HCy—HBr, or HI have been found, or if the compound suspected to contain these acids or their salts has not yielded satisfactory proofs or results, digest the well pulverized compound for some time in boiling solution of KO, add solution, of KO,CO_2, and boil again for some time, filter; pass HS through the strongly alkaline filtrate and proceed then for the detection of the acids, as described in these two Tables, previously acidifying the liquor either with $\overline{A}$,HO, or with NO_5.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

OBSERVATIONS ON TABLE XXVI.—B

Read attentively the Columns and Observations of Table XXI., and compare them with those of the present Table.

a. If the operator, instead of a fresh solution of the original compound in NO_5, takes the liquor in which HS—NH_3 and NH_4S failed in producing a precipitate, or that which has been filtered from the precipitates which may have been produced by these reagents, it is evident that he must have used HCl or NH_4Cl in the course of the preceding steps of the analysis; such a liquor will not be suitable for the present examination, at least as far as the detection of HCl in the original compound is concerned, since the addition of AgO,NO_5 would of course produce a precipitate in any case.

(Col. 3.) Read the observations on the action of nitric acid on metals. (Table II.—B., Observation *d*.)

b. (Col. 4.) Even when the quantity of iodide or of hydriodic acid is too small to produce violet fumes by treatment with NO_5, a strip of paper moistened with starch is invariably stained blue in such circumstances.

c. All metallic sulphocyanides being soluble in water, except those of lead, mercury, and silver, which are insoluble in water and in acids, $HCyS_2$ belongs scarcely to this table; yet as the original solutions may have been an acid liquid containing a sulphocyanide, it was thought advisable to notice the compound in the present table; we shall only remark that it would be useless to look for $HCyS_2$ in the original solution if it were very acid, and above all if free nitric acid was precipitated, especially after boiling the solution; since the blood colour produced by Fe_2Cl_3 in solutions of sulphocyanides is destroyed after a short time by NO_5 in the cold, and immediately if heat be applied, which colour is not reproduced by a fresh addition of a persalt of iron.

TABLE XXVII.—A.

Systematic Analysis of MIXED COMPOUNDS which are INSOLUBLE in WATER, but which are SOLUBLE in ACIDS, and which may contain both ORGANIC and INORGANIC ACIDS.

Take a small portion of the well pulverized compound, put it into a glass test-tube and pour upon the mass a small quantity of concentrated SO_3,HO, and carefully apply the heat of a spirit lamp.

Violet fumes.

I.

Obs. *a*, *b*.

Take another small portion of the well pulverized compound and fuse it with NaO,CO_2 + KO,NO_5 in a small porcelain crucible, treat the fused mass with boiling water.

Yellow liquor.

Supersaturate with NO_5.

Orange Red liquor.

Test this orange red liquid with $PbO,\overline{A}$.

Yellow.

CrO_3.

Put another small portion of the well pulverized compound into a capsule, pour upon it some concentrated SO_3,HO, stir the mass, add alcohol or wood spirit and inflame.

Greenish Yellow flame.

BO_3.

Take a portion of the well pulverized compound, or of the portion which refused to dissolve in water, treat it with cold HCl, diluted with about its own bulk of water, and observe what takes place then, and afterwards boil the whole until everything which can be thus dissolved has dissolved; filter if necessary.

EFFERVESCENCE OR NOT, with or without odour.

(See the Observations in TABLE XXVI.—A., and TABLE I.—E., Col. 3 to 9.)

Effervescence but NO ODOUR

CO_2.

and therefore carbonates only are present. Confirm by passing the gas through lime water.

Milky.

CO_2.

Obs. *c*.

ODOUR of SO_2.

Sulphites, and hyposulphites, but possibly also carbonates.

Pass the gas evolved through lime water, as in preceding Col.

Milky.

CO_2.

Obs. *c*. and TAB. I.—E., Obs. *e*, *f*.

Boil a portion of the pulverized compound for some time with NaO,CO_2 or KO,CO_2, filter, and to the filtrate add an excess of SO_3,HO.

Odour of SO_2.

SO_2.

If the clear solution becomes milky or yellow at the same time as an odour of SO_2 is evolved, the compound contains a hyposulphite, S_2O_2.

Obs. *d*.

SO_2.
S_2O_2.

ODOUR of HS.

Sulphurets, but possibly also carbonates; sulphites may also be present. See the Observations on TABLE XXVI.—A., Col. 4, 5.

Pass the gas evolved through lime water.

Milky.

CO_2.

Obs. *c*. and TABLE I.—E., Obs. *e*, *f*.

Suspend a strip of paper moistened with basic acetate of lead into the gas evolved, if it turns

Brown,

or

Black.

HS.

Sulphurets.
HS.

ODOUR of Cl.

Presence of certain peroxydes, bromates, iodates, &c., &c. See TAB. I.—E., Col. 6. Carbonates, &c., may also be present at the same time. See TAB. I.—E. Obs. *g*, *i*.

A PRECIPITATE, or insoluble portion is left.

AgO--PbO--Hg_2O, which, of course, are not here the object of research, and will have been identified before, if present. This precipitate, however, may contain $\overline{Bz}$,HO and BO_3.

Pour alcohol or wood spirit on the precipitate or insoluble portion and inflame it.

Yellowish Green flame.

BO_3.

Expose a small quantity of the insoluble portion to heat upon a strip of platinum or in a test tube.

Volatilizes with

Odour of Bz.

$\overline{Bz}$,HO.

The FILTRATE.

Evaporate a portion of the filtrate to perfect dryness, drench the dry mass with concentrated HCl, leave at rest for about ten minutes, boil the whole in water, wash and filter.

Insoluble White Gritty Powder

SiO_3.

Apply the usual tests. See SiO_3 in Dictionary.

Dilute a portion of the filtrate with water, add BaCl, boil.

White.

Insoluble in water and in acids.

SO_3.

See Dictionary. Confirm by fusing a portion of this precipitate with NaO,CO_2, upon a charcoal support. Remove the fused mass, or that portion of the charcoal on which it rested, put it on a piece of clean silver, and moisten with a drop or two of HCl.

Odour of HS.

Brown Stain.

SO_3.

Take another portion of the filtrate and put into it a crystal of FeO, SO_3, and about one-fourth of the bulk of concentrated SO_3,HO.

Brown tinge.

NO_5.

Confirm by adding to another part of the solution a few clean copper turnings, add concentrated SO_3,HO, and boil.

Ruddy fumes.

NO_5.

Obs. *e*.

Supersaturate a portion of the filtrate with KO and evaporate to dryness. Introduce the dry residue into a glass test-tube, add some alcohol and then about one-third of the volume of the alcohol of concentrated SO_3,HO; boil.

Odour of Acetic Ether.

$\overline{A}$,HO.

To another portion of the filtrate add NH_3 so as to leave a slightly acid reaction; add now one or two drops of Fe_2Cl_3 + an excess of KO,$\overline{A}$.

Gelatinous Yellowish White.

PhO_5.

Obs. *f*.

Take another portion of the well pulverized compound, or of the portion which refused to dissolve in water, and treat it with strong NO_5, previously diluted with its own bulk of water, first in the cold and then by boiling. Observe whether an effervescence is produced, or gases, or fumes evolved exactly as mentioned in TABLE XXVI.—A., Col. 2 to 6. If a great excess of acid exists in the liquor, evaporate that great excess off. Add now to the liquor a good excess of NaO,CO_2, and boil the whole for about a quarter of an hour; dilute with water if necessary, and filter. (The insoluble portion or precipitate containing the bases, and possibly some acids which have already been found, need not be kept.) Neutralize *exactly* the alkaline filtrate with dilute NO_5 and divide into THREE PORTIONS. (For the Second and Third Portions, see next Table.)

FIRST PORTION.

Concentrate this first portion by heat, add thereto some BaCl, and boil for a few minutes. (For the Second and Third Portions go to next Table.)

NO Ppte.

Go to TABLE XXVII.—B.

A PRECIPITATE is produced.

SO_3—PhO_5—CrO_3—SiO_3—BO_3—AsO_3—AsO_5—$\overline{O}$,HO—$\overline{T}$,2HO—$\overline{Ci}$,3HO—HFl—IO_5—$\overline{Qt}$,3HO—$\overline{G}$,3HO—$\overline{Me}$,3HO—$\overline{M}$,2HO.

Digest the Precipitate in HCl.

Dry a portion of the precipitate, mix it with pulverized KO, $2SO_3$ (about twice its bulk), and apply the heat of a spirit lamp.

Purple fumes.

IO_5.

Does NOT Dissolve Completely.

SO_3.

Treat the insoluble precipitate as described in Col. 13.

SO_3,

DISSOLVES Completely.

To this solution of the precipitate add as much NH_3 as will impart to it *a very slight* alkaline reaction, and then add CaCl *in the cold*.

NO PRECIPITATE.

$\overline{M}$,HO—$\overline{Ci}$,3HO.

Boil the whole, filter if necessary, (Observation on TABLE XXII.—A. Col. 4, 5), whilst it is boiling hot.

To this neutral filtrate add alcohol. (Observ. on TABLE XXII.—A. Col. 4.)

White.

Dry this precipitate and ignite it in a small glass test-tube, *a residue of* CaO,CO_2 + charcoal will be left. Confirm by treating another portion of the solution with PbO,$\overline{A}$, and boil.

Viscid mass

$\overline{M}$,2HO.

To another portion of the liquor add PbO,$\overline{A}$ in excess

White Curdy.

Very sparingly soluble in NH_3. Very soluble in citrate of ammonia.

$\overline{Ci}$, 3HO.

White Precipitate.

$\overline{O}$,HO—$\overline{T}$,2HO—HFl—PhO_5—BO_3—AsO_3—AsO_5.

Separate by filtering, and treat the filtrate as in Col. 20, 21, previously adding a little more CaCl. Divide the precipitate into two portions.

FIRST PORTION of the Precipitate.

Digest it in an excess of $\overline{A}$,HO in the cold for about a quarter of an hour.

Dissolves completely.

Add an excess of NH_3. *If no precipitate is produced no* PhO_5 *is present.* (Obs. *g*.)

RE-PRECIPITATED.

Mix a portion of the precipitate with SO_3,HO (concentrated) + alcohol; inflame.

Yellowish Green flame.

BO_3.

Boil a portion of the precipitate in an excess of KO for about a quarter of an hour, filter, supersaturate the filtrate with NO_5, add AgO,NO_5 as long as a precipitate is produced, filter, add to the filtrate a drop or two more of AgO, NO_5, and then with great care, as much NH_3 as is necessary to neutralize the acid. Observ. *h*.

Yellow.	Light Red.
AsO_3.	AsO_5.
AsO_3.	AsO_5.

Does NOT Dissolve completely, or at all.

Add HCl to the Precipitate.

Dissolves.	Does not Dissolve.
$\overline{O}$,HO. Add excess of NH_3 to this solution.	HFl. Treat this insoluble residue, or a portion of the original compnd. with concentrated SO_3, HO in a platinum capsule covered with a piece of glass, waxed, and bearing tracings. (See tests for HFl.)
White.	Corrosion
Collect and dry a portion of this precipitate, or of the original compound, and treat it in a test-tube with MnO_2 + SO_3,HO as for tests for $\overline{O}$,HO, which see	HFl.
Blue flame.	
CO, therefore $\overline{O}$,HO.	$\overline{T}$,2HO.

SECOND PORTION of the Precipitate.

Digest in excess of KO, shaking occasionally.

Dissolves	Does NOT Dissolve.
$\overline{T}$,2HO. Boil.	Filter, and treat the filtrate which may contain BO_3—AsO_5—AsO_3—$\overline{O}$,HO, &c. as described in the respective columns for those acids, which, however, will have been found long before now.
White Precipitate reappears.	
See the other tests for $\overline{T}$,2HO	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
I.	CrO_3.	BO_3.	CO_2.	CO_2.	SO_2. S_2O_2.	CO_2.	HS.		BO_3.	$\overline{Bz}$,HO.	SiO_3.	SO_3.	NO_5.	$\overline{A}$,HO.	PhO_5.		IO_5.	SO_3.	$\overline{M}$,2HO.	$\overline{Ci}$, 3HO.	BO_3.	AsO_3.	AsO_5.	CO, therefore $\overline{O}$,HO.	HFl.	$\overline{T}$,2HO.	

OBSERVATIONS ON TABLE XXVII.—A.

a. (Col. 1.) The operator will already have had occasion to observe the effect of concentrated SO_3HO on the compound in TABLE I.—C., and he will bear in mind the other reactions which will have then been produced.

b. If the compound contains iodine, or an iodide, and likewise nitrates, bromides, or bromates, and chromates mixed with chlorides, it may happen that the ruddy fumes which will be evolved in more or less abundance, may completely obscure the violet fumes of iodine, and prevent them from being recognized. But if the experiment be performed in a long test-tube, the iodine fumes, if present, will condense on the cold sides of the tube, and after allowing the latter to stand in an upright position for a few minutes, and blowing, if necessary, into it by means of a narrower glass tube open at both ends, in order to expel whatever coloured fumes may be left therein, the violet vapour of iodine will at once become apparent by heating the test-tube at the part where the black sublimate above alluded to will have taken place. (See also TABLE XXVII.—B., Observation *c.*)

Group 4 *to* 16.

c. (Cols. 4 to 5.) If the gas evolved contains carbonic acid in the proportion of only 1 per cent., the lime-water will scarcely be affected by it.

We have already said that a carbonate may be present and yet no effervescence be produced by treatment with an acid. (See TABLE I.—E., Observation *e.*) It may happen also that the disengagement of air bubbles may be mistaken for an effervescence. Wherefore, it is advisable, not only to pulverize the compound as above said, but to stir the pulverized mass well with pure water, so as to wet it thoroughly; after which the acid may be added and heat applied, which will disengage carbonic acid, if present. The gas may then be identified by lime-water as described.

d. (Col. 6.) Another good test for SO_2, consists in passing the gas through a cold mixture of iodic acid and starch, or suspending a paper moistened with this mixture above the gas disengaged, in which case a blue colour will be produced (iodide of starch), the iodic acid being decomposed by the sulphurous acid and iodine liberated; yet the operator may remember that HS produces the same effect, but HS and SO_2 cannot exist simultaneously, the latter decomposing the former with deposit of sulphur.

e. (Col. 14.) If nitric acid is found, no nitrate but that of lead (basic) can be present, since all other nitrates are soluble in water.

f. (Col. 16.) Remember that if the quantity of PhO_5 is small, several hours may be necessary for the precipitate to become visible.

Group 17 *to* 28.

g. (Cols. 22—24). If, however, phosphoric acid is present it will be necessary to operate precisely as directed in TABLE XXI., Col. 8, or TABLE XVIII., Group 3 to 15.

h. (Cols. 23, 24.) By boiling with NaO,CO_2 the base with which the acid sought for was combined will be left in an insoluble state either as a hydrated oxyde, or as a carbonate, and the acid combined with that base, which acid is now the object of the operator's research, will be found in the liquor combined with the soda employed. *The only salts which resist decomposition when so treated are the phosphates of earths.*

I have already had occasion to remark that if AsO_3—AsO_5 are present at the same time, the first impression of the NH_3 added to the solution containing AgO,NO_5 will generally be to produce a yellow precipitate of AgO,AsO_3; by adding, however, more NH_3, one drop at a time, the yellow precipitate will gradually disappear, and be finally replaced by the light brown precipitate of AgO,AsO_5. *

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* But, as in the present instance, the compound will have been treated, and probably boiled with NO_5, a great portion at least of the AsO_3, which may have existed in the compound, will have thereby been converted into AsO_5. Both these acids, however, will already have been detected in TABLE XXIII, Cols. 9, 10, where the means of distinguishing AsO_3 from AsO_5 in the original compound have been indicated.

TABLE XXVII.—B.

Systematic Analysis of MIXED COMPOUNDS which are INSOLUBLE in WATER, but which are SOLUBLE IN ACIDS, and which may contain both ORGANIC and INORGANIC ACIDS.

SECOND PORTION. (For the first portion see TABLE XXVII.—A.)
To the second portion of the alkaline filtrate exactly neutralized by NO_5 as mentioned in the preceding Table for the Group 17 to 28, add now an excess of AgO,NO_5, filter, if necessary, and treat the filtrate as if the above reagent had produced no precipitate.

NO PRECIPITATE.

Examine the liquor or the filtrate as directed in Col. 20, Observ. *a*.

A PRECIPITATE is produced.

Boil a portion of the liquor containing the precipitate in suspension; or to another portion of the exactly neutralized liquid of this second portion add AgO,NO_5 and *boil* without filtering.

PhO_5—(BO_3 if the liquor is concentrated)—$\overline{O}$,HO—HCl—HBr—HI—HCy—IO_5—$HCyS_2$—H_2Cfy—SiO_3—CrO_3—BrO_5—AsO_3—AsO_5 (See Observations on TABLE XXI., Cols. 11 to 20). Digest the precipitate in dilute NO_5.

Black powder which is metallic silver.

Dissolves completely

PhO_5—AsO_3—AsO_5—$\overline{O}$,HO—BO_3—CrO_3—SiO_3, all of which acids will have been detected by the operations of the preceding Tables.

Does NOT DISSOLVE completely, or at all.

HCl—HI—HBr—HCy—$HCyS_2$—H_2Cfy—BrO_5—IO_5. Filter, and if the filtrate contains anything, treat it precisely as if the precipitate had completely dissolved, though, as this filtrate contains only the acids in Col. 3. which have already been detected, it need not be examined again. Wash the insoluble precipitate, and heat it with a pretty large excess of NH_3.

To another portion of the solution exactly neutralized add Hg_2O,NO_5.

A precipitate becoming **Grey or Black** from a reduction of the metal. Observ. *b*.

$\overline{FoO_3}$,HO.

Does NOT dissolve completely or at all.

Observ. on Cols. 11, 12, TABLE XXI. Filter, and treat the filtrate as if the precipitate had completely dissolved.
HI—$HCyS_2$.

Dissolves completely.

HCl—HBr—HCy—BrO_5—IO_5. Add thereto an excess of NO_5.

RE-PRECIPITATED.

Dry a portion of this precipitate, mix it with $KO,2SO_3$, put the mixture into a glass tube and apply heat.

Purple Fumes.

HI.
Observ. *c*.

HI.

Take another portion of the dry precipitate and add thereto some concentrated SO_3,HO *in the cold*.

Hyacinth Red Fumes.

A red hot splinter plunged into the tube is

Rekindled.

Treat the mass in the tube with about ten times its bulk of water, add a little ether, shake and leave the whole at rest for a few minutes; the ether at the top has a

Brown or Yellowish Tinge.

BrO_5.
See TABLE VII., Cols. 22, 23.

BrO_5.

If NO BrO_5 nor I have been found,

Wash the precipitate, transfer a portion of it whilst still moist to a porcelain capsule, dry it, and ignite it in a small test tube (Obs. *y*, on Col. 15., TABLE XXI.) Boil the residue with NO_5, and filter.

A residue is left.

HCl.
This residue is AgCl, treat it as directed in TABLE XIII., Col. 3.

HCl.

The Filtrate.

Add to the filtrate some HCl.

White.

HCy.
Confirm by testing the original solution with FeO,SO_3+KO+ excess of HCl, also by NH_4S_5, as described in the tests for HCy which see.

HCy.

If Br or I have been found.

Test the original solution with FeO,SO_3+ one or two drops of Fe_2Cl_3+ an excess of KO+ an excess of HCl.

Blue.

HCy.
Confirm by testing with NH_4S_5 as described in the tests for HCy, which see.

Blood Red Colour.

See Col. 5.

HCy.

To another portion of the original liquor add an excess of a solution of one part of crystallized $CuO,SO_3+2\frac{1}{4}$ parts of FeO,SO_3 in crystals.

Dingy White Precipitate. (Cu_2I.)

Having thus removed the iodine, remove the excess of CuO,SO_3 employed by adding a solution of KO, filter, evaporate to dryness, mix with $KO,2CrO_3$, pulverize the mass, and introduce it into a glass tube, pour upon it some SO_3,HO and proceed as directed in TABLE I.—C. Cols. 27, 28.

Hyacinth Red Fumes

These fumes are bromine, and may be separated by ether, as described in tests for HBr.

HBr.

Blood Red Liquor distils.

HCl.
Observ. *d*.

HCl.

To another portion of the original solution add strong NO_5 and a solution of starch in the cold.

Blue.

Or treat a portion of this insoluble precipitate with concentrated SO_3,HO as in TABLE I.—C., Col. 30.

Purple Fumes.

HI.

To another portion of the original solution add Fe_2Cl_3.

Blood Red Colour.

To the blood red colour liquor add solution of corrosive sublimate.

This blood red colour is destroyed, and a MILKY-WHITE precipitate produced.

$HCyS_2$.

$HCyS_2$.

IO_5.

THIRD PORTION.
To the third portion of the original solution previously neutralized exactly by NO_5, as mentioned in the preceding Table for the group 17 to 18, add now some Fe_2Cl_3,

Light Brown Bulky Precipitate.

$\overline{Bz}$,HO—$\overline{S}$,HO.
Decant the superincumbent liquid, pour upon the precipitate an excess of NH_3, boil and filter, add alcohol, and divide into two portions.
(Observation *a*, on TABLE XXII.—B.

FIRST PORTION.
To this first portion of the alcoholic filtrate add BaCl.

White.

$\overline{S}$,HO.

O.

$\overline{Bz}$,HO.

SECOND PORTION.
Add a slight excess of HCl.

O.

$\overline{S}$,HO.
See TABLE VIII., Col. 9.

$\overline{S}$,HO.

Milkiness or White precipitate.

$\overline{Bz}$,HO.

$\overline{Bz}$,HO.

Black.

$\overline{Qt}$,3HO, $\overline{G}$,3HO, See TABLE XXII.—A., Cols. 17, 18.

$\overline{Qt}$,3HO, $\overline{G}$,3HO.

Blood Red Colour.

$\overline{Me}$,3HO—$HCyS_2$
Pour a solution of corrosive sublimate.

Decolorized.

$HCyS_2$.

Remains of a blood red colour.

$\overline{Me}$,3HO.
See TABLE XXII.—A. Col. 19.

$\overline{Me}$,3HO.

and a milk white precipitate is produced,

Dark Red Colour.

$\overline{A}$,HO—$\overline{FoO_3}$,HO.
Boil and leave at rest for about ten minutes.

Reddish Brown precipitate.

Neutralize some of this third portion, evaporate it to dryness, put a little of the dry residue into a glass test tube, add concentrated SO_3,HO and apply heat.

Odour of vinegar.

$\overline{A}$,HO.
(See Observ. on Col. 11. TABLE VIII.)
Or add to the dry residue just spoken of some alcohol + one-third of the bulk of the alcohol of SO_2,HO and boil.

Characteristic odour of acetic ether.

$\overline{A}$,HO.

Effervescence, the gas burns with blue flame.

$\overline{FoO_3}$,HO.
or mix a portion of the solution with SO_3,HO diluted, and condense what distils over, neutralize the distillate with NaO,CO_2 and test with Fe_2Cl_3.

Blood Red Colour.

Or test another portion of the same neutralized distillation with AgO,NO_5 and boil.

Black powder of reduced silver.

$\overline{FoO_3}$,HO.

FoO_3,HO.

If in the course of this investigation HCy—HBr or HI have been found, or if the compound being suspected to contain these acids, or their salts, has not yielded satisfactory proofs or results, digest the well pulverized compound for some time in a boiling solution of KO, add solution of KO,CO_2 and boil again for some time, filter, pass HS through the alkaline filtrate; filter again: acidify *this* filtrate with either $\overline{A}$,HO, or with NO_5, filter again, if necessary, and then proceed with the detection of the acids as described in TABLE XXII.—A. and B. As to the precipitate, were it necessary to test it for bases, it may be redissolved in NO_5 and proceeded with as in TABLES XXIII., XXIV., XXV.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

OBSERVATIONS ON TABLE XXVII.—B.

Group 1.

a. (Col. 1.) Though it is necessary to employ an excess of AgO,NO_5 to make sure that everything which can be removed by this reagent has been precipitated, yet the quantity employed should not be much greater than is required for the purpose, since cyanide of silver being soluble in a large excess of AgO,NO_5 might thus escape detection if in small quantity.

Group 2 *to* 12.

b. (Col. 2.) The presence of formic acid may also be identified by evaporating the neutralized compound by means of a steam-bath, and heating the dry residue with an excess of concentrated sulphuric acid in a test-tube provided with a disengagement tube; the gas evolved under this treatment is pure CO, which can of course be inflamed, and burns then with its characteristic blue flame. The reaction is as follows:—

Formic Acid.

$$\overbrace{C_2HO_3,HO} + SO_3,HO = \begin{matrix} 2CO \\ + \\ SO_3,3HO. \end{matrix}$$

c. (Col. 4.) A portion of the insoluble precipitate may also be mixed with a little peroxyde of manganese, and the powder being then moistened with a mixture of equal bulks of oil of vitriol (SO_3,HO) and water, is transferred to a glass test-tube, and heated therein; purple fumes are then immediately given off. By using a tube of a small bore, exceedingly small quantities of iodine may be thus rendered apparent. (See TABLE XXVII.—A., Observation *b*.)

d. (Col. 10.) The heavy deep red liquid, resembling bromine, which thus comes over is bichromate of perchloride of chromium, $CrCl_3,2CrO_3$, frequently called, also, chlorochromic acid, in which case the compound is looked upon as a chromic acid, in which one equivalent of oxygen is replaced by one equivalent of chlorine, thus:—

$$CrCl_3,2CrO_3 = 3CrO_2Cl.$$

It is a powerfully oxydizing agent, and is soon decomposed by water into CrO_3 and HCl.

Systematic Analysis of MIXED COMPOUNDS which are INSOLUBLE (or nearly so) in WATER and in ACIDS.

The insoluble substances belonging to this Table and in TABLE XXVIII.—B. may be the original compound itself, or they may be the residues left in an insoluble state after treatment with water and with acids, or they may be residues produced by the action of the acids employed upon the compound, such as, for example, sulphur, or sulphate of lead, or peroxyde of tin, by the action of NO_5 upon certain sulphurets, or upon other compounds, or of chloride of silver, or of lead, &c., by the action of HCl upon certain compounds. However this may be, if the residue, or insoluble compound, be

White.

Presence of Hg_2Cl—PbCl—AgCl—AgCy—AgI—PbO,SO_3—CaO,SO_3—StO,SO_3—BaO,SO_3—SiO_3—CaFl; and likewise certain acid phosphates and arseniates after ignition, and SnO_2 (Observation *a*.)

Take a small portion of the compound and expose it on a small strip of platinum foil to the heat of a spirit lamp.

Turns dark, burns with a blue flame, and an odour of SO_2; volatilizes entirely. (Observation *b*.)

S is certain. Possible presence of Hg_2Cl and of PbCl. (Obs. *b*.) Transfer to a small test tube, a portion of the compound, and apply the heat of spirit lamp. (Observ. *c*, *d*, *e*, *f*.)

Volatilizes completely.

S—Hg_2Cl and a sublimate is produced, which is

Yellow. S. Pour some fuming NO_5 in the tube, boil and test with BaCl.

White. Hg_2Cl. (Obs. *e*.) Pour a little NH_3 on this white sublimate.

White. Insoluble in water and in acids. SO_3 and consequently S. (TABLE VII., Obs. *g*,)

Black. Treat a portion of the compound in a test tube with NaO,CO_2 as in TABLE I.—A. Col. 16, and TABLE XIII., Col. 1.

A yellow liquid remains.

PbCl. Increase the heat to a good red heat.

Thick White Fumes. If S and Hg_2Cl are present, expel both by heat, and then pour NH_3 on the liquid residue of a yellow colour in the tube.

O. Add NH_4S.

Black. PbCl. Observ. *g*, *h*, *i*.

S Hg_2Cl PbCl

Volatilizes entirely without fusion. Hg_2Cl. Pour a few drops of NH_3 on the compound.

Black. Hg_2Cl. The volatilized portion is yellow whilst hot, and white when cold. Confirm by fusion with NaO,CO_2 as in Col. 2.

Hg_2Cl

Fuses but does NOT volatilize. AgCl. Fuse a small portion of the compound with about four times its weight of NaO,CO_2 in a glass test tube by spirit lamp + blow-pipe. Treat the fused mass with HO, filter, acidify with NO_5 and test with AgO,NO_5

White Curdy. Immediately soluble in NH_3 presence of Cl,—boil the insoluble portion in the tube with NO_5, filter and add HCl to the filter.

White Curdy. Ag. (Obs. *i*.)

AgCl.

Does NOT volatilize nor fuse. PbO,SO_3—CaO,SO_3—SnO_2 and the rest of the white compounds mentioned above. Fuse a portion of the compound with NaO,CO_2 + KCy before blowpipe on a charcoal support, if a metallic bead is obtained, treat the compound as described from Col. 12—18. If no metallic bead is obtained as from Col. 19—21. (Obs. *j*.)

Mix a portion of the compound with concentrated SO_3,HO in a platinum crucible, covered with a piece of glass coated with wax bearing tracings as described in TABLE VII., Col. 9.

Corrosion.

HFl. Evaporate the SO_3 completely from the mass in the platinum crucible, treat the mass with boiling water, filter and treat the filtrate with $NH_4O,\overline{O}$.

White. $CaO,\overline{O}$.

CaFl.

Take another portion of the compound and fuse it with NaO,CO_2 before the blow-pipe on a charcoal support.

Odour of garlic.

AsO_5. To detect the base of the arseniates the compound may at once be boiled with SO_3 (concentrated) and the base may be sought for in the solution previously diluted with water.

Arseniates.

Take another portion of the pulverized compound, carefully dry it in a glass test tube until all moisture has been expelled; drop now into the mass in the tube a small piece of metallic potassium well dried with a towel, and cautiously heat the whole over a spirit lamp. Empty the contents of the tube upon a porcelain slab, or crucible cover, and breathe upon it.

Odour of garlic.

PhO_5.

Phosphates.

Boil another portion of the compound with solution of KO. If the mass becomes

Brown,

Or

Reddish,

Or

Grey,

Or

Black.

Hg_2Cl. Confirm by fusing a small portion of it with NaO,CO_2 as described in TABLE I.—A. Col. 16., or boil it with concentrated NO_5, and test the solution or liquor as described in tests for HgO, which see (Obs. *k*.)

Hg_2Cl.

Boil the compound reduced into as fine powder as possible with about five hundred times its weight of water, after boiling for some time filter and divide the filtrate into two portions.

FIRST PORTION. Test with solution of BaCl.

White. Insoluble in water and in free acid.

SECOND PORTION. Test with $NH_4O,\overline{O}$.

White. CaO,SO_3. (Obs. *h*.)

CaO,SO_3.

Take a small portion of the white compound or residue and pour upon it a few drops of NH_4S—. If the mass turns

Yellow, Sn. **Remains White.** Absence of metals.

To place however the presence or absence of metals beyond doubt, mix a portion of the white mass under examination with NaO,CO_2 + KCy before reducing flame of blow-pipe on charcoal. (Obs. *h*.)

Metallic bead. Dissolve in NO_5 and proceed as from Cols. 12—18.

No metallic bead. CaO,SO_3—StO,SO_3—BaO,SO_3—CaFl—SiO_3.

If no metallic bead is produced,

Boil a portion of the compound with water, for some time, filter, and test the filtrate with BaCl and with $NH_4O,\overline{O}$, precisely as in Col. 11. for the detection of CaO,SO_3. Take another portion of the compound and treat it with concentrated SO_3,HO, proceed as described in Col. 7. for the detection of CaFl.

CaO,SO_3. CaFl.

If no metal is present a platinum crucible may be used, mix therefore one part of the well pulverized compound with two parts of NaO,CO_3 and two parts of KO,CO_2, put the mixture in a platinum crucible and keep the whole mass therein in a state of perfect fusion for about ten minutes, allow the fused mass to become cold—soak it with the crucible in hot water in order to soften it, replace the liquor by more hot water, and boil, adding water until all that can be dissolved by this menstruum has been taken up. Filter in order to separate the dissolved from the insoluble part and wash that insoluble portion *thoroughly* (The washing need not be kept).

The filtrate.	The insoluble residue.
Supersaturate with HCl and examine for SiO_3 and for SO_3 exactly as described in Col. 12., and for the base as in TABLE XXV. Cols. 2, 3, 4. CaO,SO_3.—BaO,SO_3.—StO,SO_3.—SiO_3.—SO_3.	Dissolve the well washed residue in NO_5, and proceed exactly as in Col. 18.

Black,

Certain presence of PbO,SO_3—PbCl—Hg_2Cl—AgCl—AgCy—AgI, possibly SnO_2, either, or all of them, alone or mixed with some or all of the earthy salts enumerated above. Mix a portion of the well pulverized white compound or residue with NaO,CO_2 and heat the mixture in the blue, or reducing flame of the blow-pipe on a charcoal support.

Metallic bead.

Pb—Ag - possibly also Sn—Treat the metallic bead by NO_5.

Becomes milky, or white precipitate is left Sn. Test as described in Col. 6.

(Filter, if necessary, in order to separate the SnO_2 if present) and to the clear solution add HCl.

White.

Pour an excess of NH_3 on this white precipitate.

White precipitate remains. Pb. Filter and treat filtrate as if the precipitate had dissolved.

White precipitate immediately disappears. Add to the clear ammoniacal liquor an excess of NO_5; if this reproduces the precipitate, Ag is present.

If a metal has thus been discovered to exist in the compound, take one part in weight of the latter well dried and well pulverized, and mix it intimately with about four parts in weight of NaO,CO_2 in a small porcelain crucible, keep the mass for some time in a state of fusion therein which may be most conveniently done by my blow-pipe gas furnace. (Observation *m*.) When the fused mass has become cold, digest it in hot water, in order to soften it, after some little time add more hot water, and when the soluble parts have all been taken up by boiling with water, filter in order to separate the dissolved from the insoluble portion, wash the latter thoroughly, that is until the water used in washing no longer turns reddened litmus paper blue; the washing need not be kept.

The Filtrate.

Divide into two portions.

FIRST PORTION. Add HCl to supersaturation (if whilst adding HCl a flaky precipitate at first appear, it is due to SiO_3 which either existed in the compound or as been formed at the expense of the crucible—in such a case acidify the liquor and evaporate it to perfect dryness, boil the perfectly dry mass with water, and filter). But whether silicic acid was present or not, test the clear acid liquor by BaCl.

White. Insoluble in water, and in acids. SO_3. Therefore, PbO,SO_3, or Earthy sulphates.

SECOND PORTION. Supersaturate with NO_5—filter if necessary, and to this acid filtrate add AgO,NO_5.

A Precipitate.

AgI—AgCy – AgCl or PbCl. Decant carefully and treat the decanted fluid as if no precipitate had been produced, wash the precipitate with water by decantation, add to it a large excess of NH_3, and heat.

Does NOT dissolve completely or at all. Filter and treat the filtrate as if the precipitate had completely dissolved. Dry the precipitate and heat it in a glass tube with $KO,2SO_3$.

Violet Fumes. I, therefore, AgI.

Dissolves completely. HCy—HCl. Add excess of NO_5.

Re-precipitated. Wash the precipitate, dry it well in small porcelain crucible, and finally ignite it. Boil the residue with NO_5 and filter (See Observ. on Cols. 15, 16, TABLE XXI.)

Insoluble residue. AgCl. AgCl.

Filtrate. Add HCl.

White precipitate. AgCy. AgCy.

No precipitate.

Possible presence of PhO_5,—AsO_5, the first of which existed in the combination in the state of metaphosphate—Neutralize exactly with NH_3.

A precipitate.

(Observation *n*.) Take a fresh portion of the original compound, well pulverized, and treat it as described in col. 24 of TABLE XIII.

PhO_5. PhO_5.

AsO_5. AsO_5.

The washed Residue.

Dissolve in NO_5 not using much more acid than is necessary, and submit it to a stream of HS to supersaturation, a black precipitate will of course be produced by the presence of Ag—Pb or Hg, which however will have been detected before. Filter, concentrate by heat and examine the filtrate for the earths as described in TABLE XXV. (Observation *o*.) If NO_5 leaves a white residue it is probably SnO_2.

Yellow. See next TABLE XXVIII.-B.

Or otherwise coloured.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

OBSERVATIONS ON TABLE XXVIII.—A.

a. SnO_2—Hg_2Cl—AgCl, instead of being white are sometimes yellow; this is the case for the first, after strong ignition; for the second, after trituration; for the third, after melting, and when in that state they belong to TABLE XXVIII.—B.

Group 1 *to* 6.

b. (Cols. 1 to 3.) The sulphurets of arsenic burn also with a blue flame like sulphur, but they are less volatile, and the platinum foil, if thin, is invariably fused by the operation.

c. If heated in a glass tube, as described, sulphuret of arsenic volatilizes completely, but much less readily than sulphur, and it condenses lower down in the tube than is the case with sulphur; the condensed portion, moreover, is always—and remains—of a dark red colour.

d. If both sulphur and sulphuret of arsenic exist in the compound under examination, the sublimate at the upper part of the tube is yellow, and consists of sulphur, whilst lower down, the sublimate is, and remains, of a dark red colour.

e. If Hg was present at the same time, the sublimate at the lowest part of the tube is more or less black, or even of a metallic appearance.

f. The operator will recollect that calomel (Hg_2Cl), sulphurets of arsenic, and sulphur, are all soluble in NO_5, and that in dissolving in that acid the calomel (Hg_2Cl) is converted into corrosive sublimate (HgCl) and pernitrate of mercury (HgO,NO_5), which is no longer capable of being precipitated by HCl. The sulphur, or at least a portion of it, is converted into sulphuric acid (SO_3). Sulphurets of arsenic are decomposed and transformed into arsenic acid (AsO_5).

g. (Col. 3.) The presence of lead, and, indeed, of mercury and silver, will already have been detected in the preliminary examination, TABLES I.—A. and I.—B.

h. Chloride of lead (PbCl) being even more soluble in water than CaO,SO_3, is not likely to be present here, for it will doubtless have been detected in the solution resulting from the treatment of the compound by water; 1 part of PbCl dissolves in 33 parts of hot, and in 135 parts of cold, water, and it deposits accordingly from its hot solution in beautiful crystals, which are in the shape either of acicular hexaedrons, or of micaceous-looking plates.

i. (Col. 5.) The presence of silver and of lead may, besides, be readily detected by fusion with NaO,CO_2 before the blow-pipe on a charcoal support, a metallic bead being thus immediately obtained which may be easily identified either as lead alone or as a mixture of lead and silver, by dissolving the bead in NO_5, and testing the solution obtained with the usual reagents, as described in several of the preceding Tables, for example, in TABLE XXIII., Cols. 2 to 4.

j. (Col. 6.) It is of the utmost importance to ascertain first that no reducible metal is present, since. should any such metal exist in the compound, the platinum crucible, if used, would infallibly be destroyed, or more or less seriously damaged. In such a case, of a metal being present, a small porcelain crucible must be used instead.

k. (Col. 10.) By boiling with concentrated NO_5, subchloride of mercury (Hg_2Cl) is converted, as we have already said (Observation *f*), into perchloride and pernitrate of mercury ($HgCl + HgO,NO_5$).

Group 12 *to* 18.

l. The mass to be fused should not be exposed to too great a heat at first, because it might then swell and boil over.

m. Instead of 4 parts of a mixture of $NaO,CO_2 + KO,CO_2$, 3 parts of $NaO,CO_2 + 1$ part of KCy may be used, but in that case, it is clear that the fused mass must be boiled with the NO_5 employed to supersaturate the liquor until all odour of HCy has completely disappeared, since, otherwise, the subsequent addition of AgO,NO_5 would produce a white precipitate of AgCy, which would simulate the presence of HCl.

n. (Col. 16.) If the precipitate produced by AgO,NO_5 is reddish brown, it is due to the presence of AsO_5; but this acid will have been already detected in Col. 8. Arsenite of silver is yellow, but the operator cannot make a mistake, since all arseniates are soluble in water or in acids.

o. (Col. 18.) If any earths are found to be present in the solution in NO_5 of the well washed residue, they must probably have been in the state of sulphates, or, possibly, of strongly ignited phosphates or arseniates, since all the other salts of the earths are more or less soluble in water or in acids.

TABLE XXVIII.—B.

Systematic Analysis of MIXED COMPOUNDS which are INSOLUBLE IN WATER AND IN ACIDS.

If the compound or residue alluded to at the beginning of the preceding Table, instead of being white, be

Yellow. | **Black.** | **Red.** | **Green.** | **Brown.** | **Otherwise Coloured.**

Whatever may be the colour of the compound or residue under examination, if it be OTHERWISE than WHITE, it may contain sulphur or sulphurets of arsenic, sulphurets or sub-chloride of mercury, peroxyde of iron, chloride and iodide of silver, sesquioxyde of chromium, peroxyde of tin, various forms of carbon, and besides these, a certain quantity of all those white compounds mentioned in the preceding TABLE, and the colour of which may be masked or overpowered by the darker hue of the compounds just enumerated. If, therefore, the compound has any other colour than white, and has not been already satisfactorily identified, proceed as follows:—Reduce a portion of the compound to as fine a powder as possible, take twenty or twenty-five grains of it (or less if that quantity cannot be spared), and boil with half-an-ounce of aqua regia until about three-fourths of it has evaporated, dilute with a moderate quantity of water, boil, and filter whilst hot. (If yellow lumps of S make their appearance, they may be at once picked off, and identified as such, as in TABLE XXVIII.—A., Col. 1.)

It may be S—AsS—SnO_2—AgCl—Hg_2Cl—Fe_2O_3,HO. (Observation *a*.)

Take a portion of the compound, and expose it to a red heat in the flame of a spirit lamp, upon a thin piece of platinum foil.

Put a small portion of the compound into a test-tube, and expose it therein to the heat of a spirit-lamp. (See TABLE XXVIII.—A., Observations *a* to *g*.)

Fuses and turns Brown.

Fuses, but does NOT Volatilize.

Dry a portion of the compound, and mix it with some $KO,2SO_3$, transfer the mixture to a glass test-tube, and heat it very strongly therein.

Violet Fumes.

AgI.

Confirm the presence of Ag by reducing the compound before the blow-pipe on a charcoal support, with NaO,CO_2+KCy, dissolving the metallic bead obtained in NO_5, and testing the solution with HCl, which will then produce a precipitate, and with NH_3, which will immediately dissolve that precipitate.

AgI.

Fuse a small portion of the compound with about four times its weight of NaO,CO_2 in a glass tube by spirit-lamp flame, urged by blow-pipe. Treat the fused mass with HO, filter, acidify with NO_5, and test with AgO,NO_5.

White, Curdy.

Immediately soluble in NH_3.

Cl.

Boil the insoluble portion of the fused mass with NO_5, filter, and to the filtrate add HCl.

White, Curdy.

Immediately soluble in NH_3.

Ag, therefore, AgCl.

AgCl.

Volatilizes Completely without FUSION.

Hg_2Cl.

The sublimate, *whilst hot*, is

Yellow.

After cooling, it is

White.

Pour a few drops of KO or of NH_3 on the sublimate.

Black.

The presence of mercury may, besides, be detected by fusion with NaO,CO_2, as described in TABLE I—A, Col. 16, and the presence of Cl may be identified by boiling the fused mass with NO_5, and testing with AgO,NO_5, as described in TABLE XIII., Col. 1.

Hg_2Cl.

Does NOT Fuse NOR Volatilize.

SnO_2—Fe_2O_3,HO.

Mix a portion of the compound with NaO,CO_2+KCy, and fuse it on a charcoal support before the blow-pipe.

Metallic Bead.

Sn.

Dissolve the metallic bead, but not entirely, in HCl, and test the solution with $AuCl_3$. (TABLE II.—B., Observation *g*.)

Purple.

Sn.

SnO_2.

O.

Fuse a small portion of the compound, well pulverized, with about four times its weight of a mixture of equal parts of NaO,CO_2 +KO,CO_2, in a small platinum capsule (*if a metal is present, a porcelain capsule must be used*), boil the fused mass with water, acidify the whole with HCl, and test with K_2Cfy.

Prussian Blue.

Fe_2O_3.

Fe_2O_3.

Fuses and Volatilizes Completely.

AsS—S, but possibly, also, Hg_2Cl.

The mass, in fusing, becomes

Dark Brown,

Black.

The sublimate nearest the mouth of the tube is

Lemon Yellow;

lower down, and whilst hot,

Dark Brown.

when cold,

Lemon Yellow.

S, alone.

Test for the other characteristics of S as in Col. 1, and Dictionary. S.

The sublimate whether when hot or when cold is

Dark Brown.

AsS.

If mixed with free S, the latter will volatilize at a lower heat, and will condense nearer the mouth of the tube, with a characteristic lemon yellow colour.

Confirm for As by fusing with NaO,CO_2, on charcoal support, before blow-pipe.

Odour of Garlic.

AsS.

The sublimate near the bottom of the tube is

Black.

Hg_2Cl.

If either AsS or S are present, there will be above the black sublimate of HgS a yellow or dark brown sublimate of S or of AsS.

The presence of mercury may, besides, be confirmed as in Col. 5.

Hg_2Cl.

S

alone is probably present. See, besides, Cols. 6 to 9.

S.

AsS;

but S may also be present in a free state, see, therefore, from Cols. 6 to 9.

AsS.

The Filtrate.

If the filtrate on cooling deposits fine brilliant crystals, they are probably PbCl, and may be identified as such, by following the directions in TABLE XXVIII.—A. Col. 3. (Obs. *b*.)

PbCl.

Evaporate the filtrate to very thick sirupy consistence, and redissolve in water.

To a portion of the solution add dilute SO_3.

White.

Pb.

Confirm by pouring NH_4S on this white precipitate.

Black.

Pb.

This Pb may have existed in the compound in the state of PbCl, or in that of PbO,SO_3. (Obs. *b*.)

Pb.

Neutralize the portion of the liquor if necessary, so that it may have only a slight acid reaction, and put a drop of it on a piece of clean metallic gold, touch the gold through the drop with a piece of clean iron.

White stain,

becomes like shining silver by friction.

Hg.

Hg_2Cl.

Submit the rest of the filtrate to a regular systematic analysis as described in TABLES XXIII., XXIV., XXV.

The Insoluble Residue.

Mix a portion of the insoluble residue with NaO,CO_2 + KCy, and fuse before the blow-pipe on a charcoal support,

Metallic Bead.

Pb—Sn—Ag.

Confirm. Dissolve the metallic bead in HCl and test with $AuCl_3$ for Sn. If the metallic bead is insoluble in HCl, dissolve it in NO_5 and test for Ag and Pb with HCl, and NH_3. (Obs. *c*, *d*.)

Take another portion of the insoluble residue, mix it with NaO,CO_2 and fuse it before the blow-pipe on a charcoal support.

Odour of Garlic.

As.

See TABLE XXVIII.—A. Col. 8.

Arseniates.

Take another portion of of the insoluble residue, carefully dry it; when all moisture has been expelled transfer to a test-tube and drop upon the mass a small piece of metallic potassium, previously dried with a towel, heat the whole cautiously over a spirit-lamp; empty the contents of the tube upon a porcelain slab, or crucible cover, and breathe upon it.

Odour of Garlic.

PhO_5.

Phosphates

If this insoluble residue be

White.

Pour upon it a few drops of NH_4S.

Black.

Certain presence of a metal.

Proceed exactly as described in TABLE XXVIII.—A. Col. 12 to 18.

Remains White.

Absence of metals.

Proceed exactly as described in TABLE XXVIII.—A. Col. 19 to 21.

Green.

Cr_2O_3 will have probably been already detected in the preliminary examination in TABLE I.—B.

Fuse a small portion of the residue with borax on a platinum hook before the blow-pipe.

Green Bead.

See TABLE XIII. Col. 23.

Cr_2O_3.

Black.

Fuse some nitre in a glass test-tube, and when in perfect fusion, project a little of the black residue into it.

Deflagration.

C.

Incinerate.

If a residue be then left examine it as in Col. 18, 19.

O.

Fuse with about two parts of NaO,CO_2+ two parts of KO,CO_2 in a platinum or porcelain crucible, as the case may be, in fact, as described in TABLE XXVIII.—A. Col. 19, 21.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

OBSERVATIONS ON TABLE XXVIII.—B.

a. All the remarks made on TABLE XXVIII.—A. apply here, the student is, therefore, advised to read them over carefully.

b. (Cols. 11, 12.) If PbO,SO_3 existed in the compound, boiling with aqua regia will have converted it into PbCl, because in a liquor which contains an excess of HCl, PbCl is less soluble than the sulphate of the same metal.

c. (Col. 15.) The insoluble residue can hardly contain Sn, unless the aqua regia employed contains NO_5 in excess, since aqua regia containing, as it should, an excess of HCl, produces only $SnCl_2$, and no SnO_2.

d. Pb and Ag may be present in the insoluble residue, and, therefore, the metallic bead obtained being dissolved in NO_5, the addition of HCl to that solution will produce a white precipitate, immediately and completely soluble in NH_3, if Ag alone is present; but if Pb exists at the same time, a white precipitate will remain, insoluble in the excess of NH_3, which, however, will have taken up the silver. It will, therefore, be necessary to filter, and if the clear ammoniacal filtrate contains any silver, supersaturation with NO_5 will immediately reprecipitate it.

SUPPLEMENTARY TABLES.

TABLE XXIX.

Systematic Analysis of a COMPOUND which may contain ALL the INORGANIC CONSTITUENTS the properties of which are WELL KNOWN.

First examine the compound with the greatest care according to the directions given in the Preliminary Tables.

The compound is completely SOLUBLE IN WATER, or if a LIQUID it is either neutral to test-papers, or it has an alkaline reaction.

Concentrate the solution of the compound so as to reduce it to a small bulk, add moderately concentrated HCl to it and boil.

ODOUR of Cl.

Presence of one of the substances mentioned in TABLE I.—E., Col. 6. Boil until all odour of Cl. has disappeared.

(Observation *a*.)

A PRECIPITATE is produced which is not easily redissolved by an excess of HCl even by boiling.

ODOUR of HS.

Presence of a metallic sulphuret combined with an alkaline sulphuret (sulphosalt). The precipitate may consist of the separated metallic sulphuret and of sulphur, whilst the sulphobase remains in solution (Obs. *b*.) As to the usual compounds precipitated by HCl, they will have been detected when operating with the usual TABLES, see, for example, TABLE XIV., Cols. 21, 22.

NO ODOUR of HS is disengaged.

Precipitate is AgCl—PbCl—Hg_2Cl or else it is SiO_3—Ta_2O_3—TiO_2—WO_3—filter.

The FILTRATE.

Examine whether it contains any thing, and if so, go to

TABLE XXX.

The PRECIPITATE (Observation *d*, *e*, *f*.)

The presence of Ag—Pb and Hg will of course have been detected in the systematic analysis of ordinary compounds as described in TABLE XIV., Cols. 4—8 and 16. (Observation *f*.)

The presence of SiO_3 is detected in the usual way by evaporating a portion of the acid solution to dryness, in doing which it becomes at first gelatinous and eventually leaves a dry gritty insoluble powder. See TABLE XXI., Col. 20.

See besides the Observations *c* and *e*.

SiO_3.

Immerse a bar of zinc into the precipitate, or into the solution containing it; or put a portion of the moist precipitate upon a piece of zinc.

O.

Ta_2O_3.
Fuse a portion of the precipitate with microcosmic salt in the exterior flame.

Limpid, colourless glass; after cooling it becomes opaque if too much has been used.

Fuse another portion with borax.

Limpid, colourless glass, becoming milky as it cools.

Fuse with NaO,CO_2 on charcoal.

Effervescence, but no reduction.

Ta_2O_3.
(Observation *d*.)

Ta_2O_3.

Blue Colour.

TiO_2—WO_3.
If the blue colour disappears, and the precipitate or the liquor becomes white, TiO_2 alone is present. Fuse a portion of the precipitate with borax in the oxydizing flame of the blow-pipe.

Colourless glass when hot; opaque on cooling.	Colourless or yellowish glass when hot; clear and colourless when cold.
In the deoxydizing flame violet glass, which may be very dark blue, if too much precipitate has been used.	In the deoxydizing flame yellow glass whilst hot, brown glass whilst cold.

Fused on charcoal with NaO,CO_2.

Effervescence, yellowish glass when hot, greyish glass when cold, but no reduction.	Gray powder which is reduced metal.
TiO_2. (Observation *g*.)	WO_3.
TiO_2.	WO_3.

The compound is NOT SOLUBLE or NOT COMPLETELY so in WATER, but it is SOLUBLE in ACIDS.

If the compound is partly soluble in WATER filter and treat the filtrate as from Cols. 1—8., and thence as in TABLE XXX.
If it is soluble in HCl—NO_5, or aqua regia, as the case may be, the solution may contain SiO_3 (Observation *c*) a little Pb, and also all the substances alluded to in TABLE I.—E., Col. 6.
Evaporate the liquor to perfect dryness, drench the residue with concentrated HCl, after some time dilute with water, filter in order to separate the SiO_3, and if the filtrate contains anything, proceed with the analysis as described in TABLE XXX.
(Observation *e*.)

The Compound is NOT SOLUBLE in WATER NOR in ACIDS, at least NOT COMPLETELY.

If the compound is partly soluble in WATER, or in HCl, or in NO_5, or in aqua regia, as the case may be, filter and treat the filrate if it contains anything as described in Cols. 1—3, and in Col. 9. Examine also whether the insoluble portion is not a precipitate produced by the action of the acids employed, and therefore operate as directed in Cols. 2—4 to 8.
If the insoluble portion is not one of the substances mentioned in these columns, or is something besides, treat that insoluble portion exactly as described in TABLE XVIII.—A. and B., and proceed with the solution thus obtained and acidified with HCl or NO_5 (as the case may be) as described in TABLE XXX.
(Observation *e*.)

1	2	3	4	5	6	7	8	9	10

OBSERVATIONS ON TABLE XXIX.

a. (Col. 1.) If the boiling be continued until all odour of Cl has vanished, most of the per oxydes or acids mentioned in the Table, will be reduced to a lower state of oxydization, and, in that state they will be subsequently found in the solution.

When an odour of Cl is evolved, it is, as we said, a sign of the presence of the subtances already mentioned, but, of course, those substances may be present without such an odour being apparent, for the reasons given in TABLE I.—E. Cols. 8, 9, Observations *i*.

b. (Col. 2.) Remember that the metallic sulphuret held in solution by a sulphobase may be precipitated by super-saturation with HCl, without evolution of HS; though most generally the reaction is accompanied by a disengagement of that gas.

c. (Col. 5.) The silicates of alkalies are all soluble in water, but those with excess of base are more so than when they contain an excess of SiO_3, yet even then, even if the excess of SiO_3, is very large, they are still, to a considerable extent, soluble in water, only, in such a case, it is necessary to reduce them to as fine powder as possible, and to use boiling water. The double silicates of alkalies and of earths, or of metallic oxydes are insoluble.

The aqueous solution of the silicates with excess of base is always decomposed by HCl, but the SiO_3, being then sometimes completely dissolved, the separation is not very observable unless the liquor be somewhat concentrated, when it has a more or less gelatinous appearance. By evaporating the acidified liquor to perfect dryness, and treating the dry mass with water, a white gritty powder is left in an insoluble state, it is SiO_3.

See in Dictionary the tests for SiO_3, in which a list of the silicates which are soluble in HCl, or which resist the action of this and other acids, is given.

In order to place the presence of SiO_3 beyond doubt, especially when mixed with other precipitates, the best way is to fuse a portion of the precipitate with an alkaline carbonate, in a platinum or porcelain crucible, according to the exigencies of the case, (See TABLE XXVIII.—A. Cols. 12 to 18.) dissolve the residue in dilute NO_5, evaporate to perfect dryness, redissolve the dry residue in water, filter; the white insoluble gritty powder left is SiO_3, which may be identified as such by its blow-pipe characters, to which the reader is referred.

d. If the compound is soluble in HCl, it is clear that it cannot contain AgO, nor Hg_2O, nor Ta_2O_3—TiO_2—WO_3.

e. Whatever may be the acid employed to effect the solution of the compound, or to be added to the aqueous solution thereof, SiO_3, must be completely separated in the usual way, that is, by evaporation to dryness, &c., after which the filtrate is in a fit condition for analysis.

f. The presence of Pb left in solution, does not at all interfere with the progress of the analysis, and need not, therefore, be further taken account of here

g. (Col. 7.) The glass produced by fusing TiO_3, with borax in the oxydizing or exterior flame, is milk white when cold, or when heated again. In the deoxydizing, or interior flame, the bead at first is yellow, but by prolonging the blast, it becomes of a violet, or amethyst colour, which may be almost black if too much precipitate has been used.

TABLE XXX.

Systematic Analysis of COMPOUNDS which may contain ALL the INORGANIC CONSTITUENTS the properties of which are WELL KNOWN, and which are soluble in WATER or in ACIDS.

Through the aqueous solution of the compound, concentrated by heat if necessary, and acidified by HCl, and filtered if necessary, or through the solution of the compound in the proper acid (see TABLE I.—E,), and concentrated by heat if necessary, and boiled until the excess of acid has been dissipated, and, if it evolves Cl until the odour of that gas has vanished, or through the liquors or filtrates from TABLE XXIX., Cols. 3, 9, 10, pass a stream of HS, whilst the liquor is hot, until it is completely saturated with that gas. Leave the whole at rest, after supersaturation with HS, if possible in a warm place, for ten or twelve hours, and then heat it *nearly* to boiling..

NO PRECIPITATE.

Go to TABLE XXXI.

A PRECIPITATE is produced.

Ag.—Hg.—Pb.—CrO_3.—Fe_2O_3.—AsO_3—AsO_5—S—SnO—SnO_2.—Sb.—Au.—Pt.—Cd.—Cu—Bi. all of which compounds will doubtless have been detected before in the ordinary TABLES, but the precipitate may also be due to the presence of Rh.—Ir.—Os—Pd—Sb_2O_4—Sb_2O_5—MO—Te—Se (Observation *a*.), filter and keep the filtrate, if it contains anything, for further examination, that is as if it was a liquor in which HS had produced no precipitate. See Col. 1.
Wash the precipitate by decantation with water containing a little HS, and then digest it for about a quarter of an hour with the help of a gentle heat in NH_4S—(or if Cu be present, in KS. Observation *b*) and filter.

The FILTRATE.

As—Au—SnO—Sb—Pt—Mo—Se—Te—Ir. Dilute the filtrate with a little water, and add thereto a small excess of $\overline{A}$,HO which will reprecipitate all that had been dissolved by NH_4S, mixed of course with free sulphur from the decomposition of this reagent, collect the precipitate on a filter, wash it thoroughly, and then dry it at a gentle heat.

Test a portion of the dry precipitate for As and for S as described in TABLE XXIII., Col. 9, 10, 11.

Fuse another portion of the dry precipitate with microcosmic salt on a hook of platinum wire in the interior flame of the blow-pipe.

Dark blue, or black bead, while hot.

Fine green bead, when cold.

Fuse another portion with NaO,CO_2 on a charcoal support.

Grey metallic particles caused by reduction, which require however that the charcoal should be triturated and washed with water.

Mo.
See the tests in the Dictionary.

MoO.

Heat another portion of the dry precipitate on charcoal with microcosmic salt, or with NaO,CO_2.

Odour of decayed raddish.

Se.
See the tests in the Dictionary.

Se.

Mix a portion of the dry precipitate with C and KO, or with KCy, and expose the mixture to a red heat in glass test tube. Treat the mass by water, filter, and to the filtrate previously acidified with HCl, add SO_2 or solution of NaO,SO_2, and if nothing is at first produced apply heat.

Black.

Supersaturate slightly another portion of this acidified solution just mentioned with KO.

White.

soluble in an excess of KO.

Observation *c*.

TeO_2.

Dissolve the rest of the precipitate in aqua regia, evaporate almost to dryness by means of a steam or water bath, and redissolve the dry mass in a small quantity of dilute HCl, and to a portion of this solution add a few drops of NH_4Cl.

Yellow.

Pt.—Ir.
Separate the precipitate and ignite it with its own weight of KO,CO_2, treat the mass with water and then with aqua regia; filter.

The Filtrate.	The insoluble portion.
Add to the filtrate previously reduced to a very small bulk some NH_4Cl and a few drops of HCl.	Consists of metallic Ir. Mix this insoluble portion with equal weight of common salt, carefully place it in a tube connected with a flask from which Cl can be disengaged, heat it to incipient redness in the tube and when nearly red hot pass a stream of Cl over or through it, treat the contents of the tube with water and submit it to the tests for Ir, which see in Dictionary. Ir.
Yellow.	
Pt.	
Pt.	Ir.

O.

Au.
To another portion of the solution add a few drops of FeO,SO_3.

Brown precipitate,	**or bluish colour.**
Au.	
Au.	

Sb—Sn.
Treat another portion of the solution as directed in TABLE XXIII., Cols. 21, 22, 23.

Sb.
Sn.

The INSOLUBLE Portion.

Cd—Pb—Bi—Cu—Ag—Hg—Pd—Os—Rh.—All these substances except Rh will have been detected.

Dry thoroughly a portion of this insoluble portion and heat it to redness in a stream of hydrogen gas. Treat the mass afterwards with NO_5 and aqua regia, the portion which remains insoluble in those acids is Rh. Mix the metallic rhodium with pulverized $KO,2SO_3$, introduce the mixture into a test tube of hard glass, or in a porcelain crucible, and keep it therein at a red heat for some time. The mass will have, when cold, a yellow colour; treat it then by water which will become tinged yellow, and add NH_3.

Yellowish White.

Soluble in HCl. See the tests in the Dictionary.
Rh.
(Observation *d*.)

Rh.

1	2	3	4	5	6	7	8	9	10

OBSERVATIONS ON TABLE XXX.

a. The precipitates produced by HS are, of course, metallic sulphurets, some of which require a very long time to settle, whilst others will not make their appearance until heat is applied to the solution ; in all cases, however, the separation and settling are always accelerated by heat. If the higher degrees of oxydation of manganese, or chromium are present, the precipitate as is the case with Fe_2O_3 may consist of sulphur, either alone or mixed, with the precipitated sulphuret. S_2O_5—SO_2—ClO_5—BrO_5—IO_5 may also, under the circumstances, produce a deposit of sulphur owing to the decomposition of the HS.

b. If Cu is present, KS must be used instead of NH_4S, since Cu is slightly soluble in the latter reagent. The presence of Cu may be immediately ascertained by adding an excess of NH_3 to a small portion of the original solution, and filtering. The ammoniacal filtrate in that case has, of course, a beautiful blue colour if there is a sufficient quantity of Cu present; but if the quantity of Cu be small, the reaction with NH_3 may not be perceivable, in that case it is best to supersaturate the ammoniacal filtrate with $\overline{A}$,HO and then to add K_2 Cfy which will produce a crimson precipitate, or a pink colour, if there be any Cu in solution. (See TABLE XXIII., Observation *s.*)

c. (Col. 5.) If the solution of the compound obtained as directed in this column has the colour of red wine the compound may contain TeO_3 as well, this compound is distinguished from TeO_2 because the latter is precipitated by an infusion of galls, which is not the case with TeO_3, and because TeO_2 does not evolve Cl when heated, as is the case with tellurates.

d. (Col. 10.) The only noble metals besides rhodium which can thus dissolve in $KO,2SO_3$ are silver and palladium.

TABLE XXXI.

Systematic Analysis of COMPOUNDS which may contain ALL the INORGANIC CONSTITUENTS, the properties of which are WELL KNOWN, and which are SOLUBLE in WATER, or in ACIDS.

Treatment of the liquor not precipitated by HS, or of the liquor filtered from the precipitates produced by that reagent.

Take a small portion of the liquor under examination, add thereto some NH_4Cl and a slight excess of NH_3, and whether or not a precipitate is produced, add an excess of NH_4S, and leave the whole exposed to the air until the excess of NH_4S employed has dissipated.

A PRECIPITATE is produced.

Filter, and if the filtrate contains anything, treat it as if no precipitate had been formed, that is to say, as in Col. 14 to 19.

The precipitate indicates Zn—Al—AsO_5—BO_3—Mn—Co—Cr—PhO_5—$\overline{O}$,HO—FeO—Fe_2O_3—Ni, all of which substances will have been detected before, according to the directions given in TABLE XXIV.

Besides these, the following may also be present: U.—Gl—Th.—Yt—Zr.—Ce— and possibly also (if the substance is insoluble in water) certain salts of lime, baryta, strontia, and magnesia.

Wash the precipitate with water containing a little NH_3, and dissolve it, after it has been thus well washed, in aqua regia; evaporate the excess of acid, dilute with water and add SO_3,HO (diluted) and alcohol. If a precipitate be produced, add more SO_3,HO + alcohol as long as this takes place, filter, (treat the filtrate as if no precipitate had been produced.)

A PRECIPITATE

Presence of Ca. Ba. St. precipitated in the state of sulphates.

Examine at once this insoluble precipitate by fusion with NaO,CO_2, as described, TABLE XXVIII. Col. 20.

Ca. Ba. St.

NO PRECIPITATE is produced.

Add to the liquor some NH_4Cl, and then some caustic NH_3 (If a precipitate be produced, filter, and treat the filtrate as if no precipitate had been formed.)

NO PRECIPITATE.

Possible presence of Zn. Mn. Co. Ni.

Observ. *a*, Examine the liquor for those bases as directed in TABLE XXIV. Col. 14, 18, 19—24.

Zn. Mn. Co. Ni.

A PRECIPITATE is produced.

Fe.—Al.—Cr.—U.—Gl.—Zr.—Th.—Ce.—Yt.—Digest the precipitate for a somewhat long time in a large excess of caustic KO, shelter it as much as possible from the contact of the air, filter, if necessary. NO heat must be applied. (Observation *b*.)

Dissolves completely.

Al—Gl—Cr. Add a pretty large excess of NH_4O,CO_2, leave at rest for some time, shaking vigorously now and then (Observ. *c*.), filter, if necessary.

A PRECIPITATE.

Moisten a portion of the precipitate with CoO,NO_5, and heat the mass strongly before the blow-pipe upon charcoal.

Fine Blue Colour.

Al_2O_3. (Observ. *d*.)

Al.

Fuse another portion of the precipitate with microcosmic salt upon a hook of platinum wire.

Emerald Green Bead.

Cr_2O_3.

Cr.

NO PRECIPITATE.

Neutralize the liquor with HCl, and add an excess of NH_3.

White.

Perfectly soluble in NH_4O,CO_2—Gl.

Moisten a little of the precipitate produced by NH_3 with CoO,NO_5, and heat strongly on a charcoal support.

Grey or Black.

Gl.

Gl.

Does NOT Dissolve completely or AT ALL.

Fe.—U.—Zr.—Th.—Ce.—Yt. Wash the precipitate thoroughly with hot water, dissolve it in HCl, concentrate it to a small bulk by heat, add to it a very large excess of solution of $KO,2CO_2$, and leave the whole to digest for a long time, frequently shaking the mixture, filter if necessary. (Observation *e*.)

Residue is left.

Fe_2O_3.

Dissolve in HCl, dilute with water, render the solution almost neutral, and test with K_2Cfy.

Blue.

Fe_2O_3.

Fe.

The Filtrate.

To a portion of the filtrate add solution of K_2Cfy.

O.

Zr. may be present but the other bases are certainly absent.

Heat another portion of the filtrate, or the unprecipitated liquor, and while hot add KO,SO_3.

White.

Almost insoluble in water and in acids.

Zr.

See the other tests for Zr.

Zr.

A Precipitate.

If the precipitate is

Brownish Red.

U.

Fuse a small portion of this precipitate with borax in the oxydizing flame of blow-pipe upon platinum hook.

In Oxydizing flame,

Yellow Opaque Bead.

In Deoxydizing flame,

Dingy Green Bead.

With microcosmic salt,

In both flames,

Green Bead.

U.

Th.—Yt.—Ce.—U. (Of course filter, and treat filtrate as in Col. 7.) Take another portion of the filtrate to which no K_2Cfy has been added, and boil it; while boiling, add to it, a concentrated solution of KO,SO_3, dilute with a moderate quantity of water, and filter. (Observation *f*.)

An INSOLUBLE RESIDUE is left.

Heat a portion of the residue upon a platinum cover in contact with the air,

Brick Red.

A good red heat is necessary.

Ce.

Ce.—Th.

Boil the insoluble residue in a concentrated solution of NaO,CO_2, and filter if necessary.

Dissolves completely.

Th.

Submit the solution to tests for that base.

Th.

Remains almost insoluble.

Ce.

Treat as directed in Col. 9.

Ce.

The Filtrate.

Add NH_3. Filter if necessary.

Yellow.

U.

Treat the yellow precipitate as described in Col. 8.

U.

O.

Yt.

Submit the filtrate to the tests for that base.

Yt.

NO PRECIPITATE is produced.

Mg.—Ca.—St.—Ba.—K.—Na.—NH_3.—Li.

Add HCl to supersaturation, boil until all odour of HS has disappeared; filter if necessary. Add some salammoniac, if the liquor does not already contain enough of it, pour into the liquid a slight excess of NH_3, and then an excess of NH_4O,CO_2, apply heat to the mixture so that it may gently simmer for awhile.

A PRECIPITATE.

Ba. St. Ca.

Proceed as directed in TABLE XXV. Col. 2, 3, 4, 5.

Ba. St. Ca.

NO PRECIPITATE is produced.

Mg.—Li.—Na.—K.—NH_3.
Divide into Three Portions.

1ST PORTION

Add dilute SO_3, or soluton of KO,SO_3.

O.

Proof that all the Ba and St have been precipitated by the excess of NH_4O,CO_2, and it is all right. (Observ. *g*.)

2D PORTION.

Add some $NH_4O,\overline{O}$.

O.

Proof that all the Ca has been precipitated by the excess of NH_4O,CO_2, and it is all right. (Observ. *g*.)

3RD PORTION.

Add (2NaO)HO,PhO_5 and stir the whole briskly after awhile. Filter if necessary.

White.

Mg.—Li.

Filter, and treat the filtrate as in Col. 19.

Dry the precipitate and ignite, in order to expel the ammoniacal salts, add SO_3,HO to the ignited mass, and expel completely the excess of acid by a slight ignition, dissolve the mass in the slightest possible quantity of water, and add a solution of pure KO.

O.

Li. alone is present.

See the other tests for that base.

Li.

White.

Mg.

Filter, and test the filtrate for Li.

Make sure that the precipitate is Mg, by redissolving in an acid, and applying the tests for that base.

Mg.

O.

K—Na NH_3.

These bases are detected precisely as directed in TABLE XXV. Col. 7, 8.

K. Na. NH_3.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

OBSERVATIONS ON TABLE XXXI.

Group 2.

a. (Col. 2.) If nickel is present in appreciable quantity, the filtrate will have a beautiful blue colour ; if cobalt, the liquor which probably was pink before the addition of NH_3, will then have turned brown. The presence of zinc or of manganese does not interfere with either of these effects, but if nickel and cobalt are both present, the blue colour imparted by the former to ammoniacal solutions is more or less completely destroyed, and the liquor has a dingy brown colour.

Group 3 to 13.

b. It is absolutely necessary to operate in the cold with the solution of KO, since by boiling Cr_2O_3, might be precipitated.

Group 3 *to* 5.

c. (Col. 3 to 5.) A large excess of NH_4O,CO_2 must be employed, because Gl is precipitated by a small quantity of this reagent, in bulky flakes which have a great resemblance with Al_2O_3, but which are $Gl_2O_3CO_2,5HO$, and which, however, instead of being insoluble in an excess of the reagent, as is the case with Al_2O_3, are, on the contrary, pretty easily redissolved *in the cold* by a somewhat large excess of the reagent assisted by vigorous shaking. No heat must be applied, because this would reprecipitate the glucina.

d. (Col. 3.) The blue colour of the mass is well seen only by daylight, and after the mass has quite cooled. An excess of CoO,NO_5 deepens the colour, but does not impair its brilliancy. *If the Al_2O_3 is contaminated by Gl, the mass, instead of having a pure blue colour, will have a greyish or black tinge.*

Group 6 *to* 13.

e. (Col. 6 to 13.) The operator will bear in mind that $KO,2CO_2$ at first precipitates all these bases, and he must, therefore, not be in a hurry. He must also be sure to add a sufficient excess of concentrated solution of $KO,2CO_2$, because although ZrO—ThO—CeO—and YtO are soluble in that reagent, they are only sparingly so. The solution of ThO takes place more rapidly than either of the other oxydes, and in all cases the solution must be very concentrated, for otherwise even ThO is dissolved with extreme slowness and difficulty. CeO is, under any circumstances, very sparingly soluble, but this oxyde is easily recognized by the brick-red colour which it assumes when submitted to a red heat in contact with the air.

f. (Col. 9 to 13.) It is necessary to remark here that all the oxydes named, except UO and U_2O_3, are precipitated by KO,SO_3, unless the solution be very dilute. ZrO, however, is always precipitated under all circumstances by KO,SO_3.

The reactions enumerated, do not, as far as Yt is concerned, refer to Yt only, but to a mixture of the oxydes of that metal with Erbium and Terbium—and as far as Ce is concerned, to a mixture of CeO with the oxydes of Lanthanum and of Didymium.

Group 14 *to* 19.

g. (Col. 15 to 16.) If a precipitate be produced by either dilute SO_3 or a soluble sulphate, or by $NH_4O,\overline{O}$, it is a proof that the whole of these earths has not been precipitated by NH_4O,CO_2. A fresh quantity of the latter reagent must accordingly be used with the liquor, heat applied, and after having filtered, if necessary, the filtrate is to be again tested with SO_3 and with $NH_4O,\overline{O}$, after which, if these reagents have produced no precipitate, the liquor is in a fit condition to be treated as in Cols. 17, 18, 19.

TABLE XXXII.

Systematic Analysis of COMPOUNDS which may contain ALL the INORGANIC CONSTITUENTS the properties of which are WELL KNOWN.

The Compound is SOLUBLE IN WATER.

Proceed exactly as described in TABLES I.—C. and XXII.—A., XXII.—B. Divide the Liquor into Three Portions.

1ST PORTION.

To the first portion rendered very slightly alkaline as described in TABLE XXII.—A., add a solution of BaCl, and if a precipitate be produced, filter. (Observation *a*.)

The FILTRATE

may contain—
BO_3.—
$\overline{O}$,HO.—
$\overline{Ci}$,3HO.—
$\overline{T}$,2HO.

See TABLE XXII.—A. Col. 1.

The PRECIPITATE.

Presence of IO_5—SO_3—$\overline{M}$,2HO—$\overline{Ci}$,3HO—BO_3—AsO_5—PhO_5—PhO_3—$\overline{O}$,HO—HFl—$\overline{T}$,2HO—$\overline{Qt}$,3HO—$\overline{G}$,3HO—$\overline{Me}$,3HO—all of which acids may already have been detected in the TABLES above alluded to. Besides these, BrO_5—SeO_2—SeO_3 may also be present.

Dry the precipitate and introduce a portion of it into a small glass test-tube, and pour upon it a few drops of *cold* SO_3,HO.

Hyacinth Red Fumes.

BrO_5.

Apply the other tests mentioned in TABLE XXII.—B. and VII., Col. 22, 23.

BrO_5.

To another portion of the dried precipitate add $KO,2SO_3$, and apply heat.

Violet Fumes.

IO_5.

IO_5.

Take a portion of the original aqueous solution, acidify with HCl, *in the cold*, and add solution of SO_2 (Observ. *b*.), after a time,

Cinnabar Red Powder.

SeO_2.

Confirm by heating a portion of the powder with soda upon a charcoal support in the interior flame of the blow-pipe.

Odour of decayed raddish.

See also TABLE I.—C., Col. 7, and I.—A., Col. 23.

SeO_2.

Boil the original solution with HCl as long as an odour of Cl is perceived, even after adding a fresh portion of HCl, then add solution of SO_2, or of a sulphite.

Cinnabar Red Powder.

SeO_3.

Confirm by heating a portion of this red powder with NaO,CO_2 upon a charcoal support in the interior flame of a blow-pipe.

Odour of decayed raddish.

SeO_3.

SeO_3.

2ND PORTION.

The acids to be looked for in this second portion are, $\overline{Fo}O_3$,HO — SiO_3 — HI — $HCyS_2$ — IO_5 — BrO_5 — HCl — HCy — HBr — all of which will already have been detected, by following the directions of TABLE XXII.—B. Besides these, however, manganates and permanganates may be present. If the original salt or solution was—

Purple, | **Red,** | **Crimson,**

and evolved a copious odour of Cl, probable presence of a permanganate; in that case the solution, on adding HCl thereto, soon became brown and eventually was decolourized.

Evaporate to dryness, and test by fusing with NaO,CO_2, on platinum foil in the oxydizing flame of the blow-pipe.

Turquoy Blue.

See the other reactions of Mn_2O_7.

Mn_2O_7.

MnO_3

is probably present, in which case addition of HCl produces an abundant disengagement of Cl, and the liquor becomes

Purple.

The Cl is disengaged very soon after the reddening of the liquor, which, however, in a short time becomes brown.

Evaporate to dryness, and test the residue with NaO,CO_2, on a platinum foil in the oxydizing flame of the blow-pipe.

Turquoy Blue.

See the other reactions of MnO_3.

MnO_3.

3RD PORTION.

The third portion is treated exactly as in TABLE XXII.—B., Col. 13 to 18, and as in Col. 19 to 21.

INSOLUBLE IN WATER but SOLUBLE IN ACIDS.

1ST PROCESS.

Treat the compound exactly as described in TABLE XXVII.—A. and B., and submit separate portions of the solution thus obtained to special testing for the various individual acids, as described in the preceding columns.

2ND PROCESS.

If the operator has reason to suspect the presence of cyanides, bromides, or iodides in the compound insoluble in water, it is better for him to boil the well pulverized compound with solution of KO, adding solution of KO,CO_2, boiling again for some time, filtering, &c. exactly as described in TABLE XXVII.—B., Col. 20.

INSOLUBLE IN WATER AND IN ACIDS.

Examine whether the compound can be decomposed by boiling with KO and KO,CO_2, as described in Col. 9, and if so, proceed accordingly.

If, however, the compound resists decomposition, treat exactly as described in TABLE XXVIII.—A. and B., and as in TABLE XXIX., XXX., XXXI.

1	2	3	4	5	6	7	8	9	10	11

OBSERVATIONS ON TABLE XXXII.

Group 1 *to* 5.

a. The operator must bear in mind that unless the solution be very concentrated, several of these acids will not be precipitated by BaCl, or a long time will elapse before the precipitate makes its appearance.

b. (Col. 4, 5.) It is absolutely necessary to operate *in the cold*, since selenic acid (SeO_3) is not precipitated by SO_2 except after having been boiled for a long time with HCl, whilst selenious acid (SeO_2) *is at once reduced in the cold*, by treatment with a solution of SO_2, or of a sulphite, provided the liquor containing the selenious acid has been previously acidified. If nitric acid be present at the same time the liquid should be carefully evaporated so as to volatilize it, the dry residue, being then redissolved in water, may now be precipitated by SO_2 or a sulphite.

SYSTEMATIC ANALYSIS OF GASES.

TABLE XXXIII.

Systematic Analysis of GASES.

Fill a graduated gas test-tube with mercury (Observation *a* to *p*), plunge it, mouth downwards, into a mercurial trough, and raising it up, so that the mouth of the tube, full of mercury, remains only a short distance under the surface of the mercury in the trough, cause a portion of the gas to be examined to ascend through the mercury in the tube, until about three-fourths of the metal therein are displaced by the gas. Close the mouth of the tube with the thumb and transfer it to a deep cylinder of strong glass, withdraw the thumb, and immerse the tube completely in a vertical position into the glass cylinder, as represented in the figure (Observation *d*). Raise it up again, always in a vertical position, until the mercury inside and that outside the tube are at the same level, and read off the exact number of volumes or divisions occupied by the gas in the graduated tube. Fill now a pipette (see the figure in Observation *d*, and TABLE XXXIV.—B., Observ. *h*,) nearly, with a strong solution of caustic potash, introduce the bent up end of the pipette under the mouth of the glass tube, and carefully blow a portion of the potash solution through the mercury into the tube containing the gas or gaseous mixture. Remove the pipette and agitate the tube up and down the mercury in the cylinder of glass, so that the potash and the gas may come in contact as much as possible. Immerse again the tube completely under the mercury in the glass cylinder, taking care to maintain it in a vertical position, draw it out until the surface of the mercury inside and that outside the tube are at the same level, and read off again the number of volumes or divisions occupied by the gas, the loss, of course, represents the number of volumes of gas which have been absorbed by the KO.

The GAS IS ABSORBED completely.

NOT ABSORBED or only partly.

$HCl—HBr—HI—SiFl_3—BoFl_3—CO_2—SO_2—Cl—Cy—HCy—HS—SeH—TeH$. Take a fresh portion of the gas, or gaseous mixture under examination, and agitate it in the tube with a small quantity of pure distilled water. (Observ. *j* to *p*.)

Oxygen, Olefiant gas, Light carburetted hydrogen, Phosphuretted hydrogen, Arseniuretted hydrogen, Oxyde of Carbon, Nitric Oxyde, Nitrous Oxyde, Nitrogen;

but if partial absorption has taken place, some of the gases of the preceding Col. may be present also.

Go to TABLE XXXIV.

ABSORBED at once, and completely.

The gases which must be more particularly looked for are, HCl—HBr—HI—$SiFl_3$—$BoFl_3$, alone or mixed with some of these gases, or with a certain portion of the gases alluded to in Col. 6 to 12. If the gaseous mixture is completely absorbed, it should, therefore, be tested notwithstanding, for CO_2—SO_2—Cl—Cy—HS—SeH—TeH, as directed in Col. 6 to 12; also, perhaps, NO. See TABLE XXXIV.—A., Col 10.

ABSORBED, but not so completely or suddenly.

CO_2—SO_2—Cl—Cy—HS—SeH—TeH. Possible presence also of a certain quantity of the more readily absorbable gases alluded to in Col. 1 to 5.

Remove the more soluble gases from a portion of the mixture by shaking it with a small quantity of water and to the residue, add lime water. (Observation *h*.)

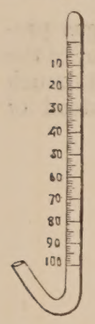
If the dissolving the gas in a small quantity of water was accompanied with a	To a portion of the solution of the gas in a small quantity of water, add alcohol, and set it on fire.	To another portion of the solution of the gas in KO, add solution of starch and some NO_5.	To another portion of the solution of the gas, in a small quantity of water, add a little chlorine gas, or of aqueous solution of Cl, and then some ether, shake the whole violently and leave at rest. If the supernatant ether has a more or less	To another portion of the solution of the gas in KO add solution of FeO,SO_3, containing a little Fe_2O_3, and then acidify the liquor with dilute HCl.	**White Precipitate, or Milkiness,** immediately soluble with effervescence in acids. CO_2. (Observ. *q*.)	**NO White Precipitate, NOR Milkiness.** If the said gaseous residue has an						
Gelatinous deposit of SiO_3.	**Green Flame.**	**Blue Colour.**	**Hyacinth Red Colour.**	**Prussian Blue.**		ODOUR of bitter almonds.	ODOUR of rotten eggs.			ODOUR of NH_3.	ODOUR of burning Sulphur.	ODOUR of Cl.	
and the liquor expressed from this gelatinous silica is hydrofluosilicic acid; presence of $SiFl_3$. (Observ. *f*.)	$BoFl_3$. (Observ. *f*.) See besides the reactions of that compound. TABLE I.—C., Col. 22.	HI.	HBr. See the tests for that acid, and the best method of operating with ether.	HCy—Cy. To a fresh portion of the gas add red oxyde of mercury; if absorption take place, completely or in part, presence of HCy.		Cy. Confirm by adding to a portion of the solution of the gas in KO, some FeO,SO_3, containing a little Fe_2O_3, then a slight excess of dilute HCl.	Set fire to the residue, or unabsorbed portion of the gas. Burns with a blue flame. Yellow deposit is left in the glass tube after burning. HS. The burning evolves an odour of SO_2. Confirm by adding some $PbO,\bar{A}$ to the potash solution of the gas.	Red powder is left in the glass tube after burning. Fuse a portion of the red powder with NaO,CO_2 in the interior flame of the blowpipe, upon a charcoal support.	Brown metallic deposit is left on the glass after burning. TeH. See the tests for TeO_2.	NH_3. The smallest quantity of this gas is always detected by the white fumes which a rod moistened with HCl produces when immersed in the gas (Observ. *s*), and by its turning red litmus-paper blue, also by its odour which is quite characteristic.	Agitate another portion of the gas with red lead. Absorption more or less. SO_2. Agitate with a mixture of IO_5 and starch. **Blue Colour.** SO_2.	Agitate another portion of the gas with tincture of litmus. Decolorized. Cl. Confirm by neutralizing a portion of the solution of the gas in KO with pure NO_5, and test with AgO,NO_5. **White Curdy,** immediately soluble in slight excess of NH_3, and reprecipitated by acids. Cl. (Observation *t*.)
$SiFl_3$.	$BoFl_3$.	H1.	HBr.	HCy.	CO_2.	Cy.	**Prussian Blue.** If the gas be in sufficient quantity, it will, on being lighted, burn with a peach-blossom coloured flame. Cy.	**Black.** HS. (Observ. *r*.) HS.	Odour of decayed reddish. SeH. (Observ. *r*.) SeH.	(Observ. *r*.) TeH.	NH_3.	SO_2.	Cl.
1	2	3	4	5	6	7	8	9	10	11	12	13	14

OBSERVATIONS ON TABLE XXXIII.

GENERAL OBSERVATIONS ON THE SYSTEMATIC ANALYSIS OF GASES.

a. The test-tubes employed for the qualitative analysis of gases, either isolated or mixed, should be made of strong glass, accurately graduated, about a foot long, and not more than half an inch in the bore, so that their mouth may be thoroughly closed with the thumb for the purpose of agitating the gas with liquid solvents or reagents, or for enabling the operator to transfer them from one vessel to another without fear of loss by leakage.

b. For the analysis of certain gases, or mixtures of gases, fountain tubes about sixteen inches long, about half an inch in the bore, and with one end bent upwards so as to act as a water valve, as represented below, will be found very convenient and almost indispensable.



For the analysis of gases which contain oxyde of carbon (CO) and with which potassium has to be heated, tubes about eight inches long, and bent at the stopped or closed end about an inch and a half or two inches from the extremity, are required, the bent part serves to receive the potassium, and such a tube, which is, in fact, a small retort, is represented here.

Fig. 1.

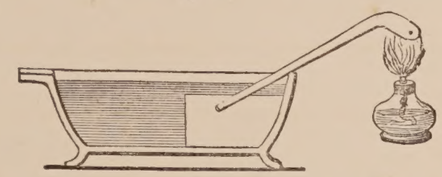
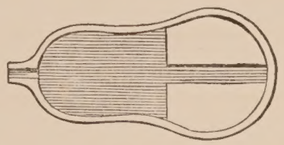
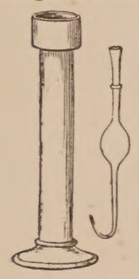


Fig. 2.



c. The form of mercurial trough which I consider to be the most convenient for the purpose is represented above, fig. 1 and 2, the first being an elevation, the other a plan thereof. When in use it should be placed in a tray, in order to collect any mercury which may be spilled.



d. The strong cylinder of glass and the bent pipette alluded to in the Table are represented in the following figures, the mercurial trough, and the glass cylinder containing mercury, should stand, when in use, in a tray of gutta percha, in order that any mercury which may be spilled should not be wasted.

e. Instead of a mercurial trough, and when mercury is not come-at-able, water frequently may be used in its place except the gases present are very soluble in water, as for example HCl—HBr—HI—HCy—NH_3—&c., or are decomposed by it, such as $SiFl_3$—$BoFl_3$.

f. $SiFl_3$ and BFl_3 are decomposed by water into hydrofluosilicic acid accompanied by a deposit of gelatinous silica in the first instance, and into hydrofluoboracic acid accompanied by a deposit of boracic acid in the second instance, thus:

$$3\,SiFl_3 + 3HO = SiO_3 + \underbrace{(2\,SiFl_3), 3HFl_3}_{\text{Hydrofluosilicic acid.}}$$

$$BFl_3 + 3HO = \underbrace{BO_3, 3HFl}_{\text{Hydrofluoboracic acid.}}$$

g. There are, moreover, some gases which cannot be collected over either mercury or water; among them are chlorine and hydriodic acid both of which attack mercury even in the cold, the chlorine combining with the mercury, and the hydriodic acid being decomposed by this metal which combines with its iodine, hydrogen being liberated. These gases should be received either in flasks full of dry air, or of water saturated with a solution of common salt.

h. Carbonic acid and sulphuretted hydrogen are scarcely soluble in a *saturated* solution of sulphate of magnesia.

i. Several other gases, though not so soluble in water as those which have been just alluded to, are nevertheless taken up in considerable proportion, at least some of them, as shown in the following list:—

One cubic inch of water dissolves about

680	cubic inches of	NH_3.
480	...	HCl.
480	...	HBr.
480	...	HI.
27	...	SO_2.
4	...	Cy.
3	...	HS.
3	...	SeH.
3	...	TeH.
1 to 3	...	Cl according to temperature.
1	...	CO_2.
0·5	...	NO.
0·20	...	AsH_3.
0·125	...	PhH_3.
0·05	...	NO_2.
0·037	...	O.

The following are insoluble, or almost so, in water:—

C_2H_4 (Light Carburetted hydrogen).
C_4H_4 (Olefiant Gas).
CO.
SbH_3.
N.

j. It is evident that several of these gases cannot exist simultaneously; for example, oxygen cannot exist in presence of nitric oxyde; free NH_3 cannot, of course, exist in presence of gaseous acids, nor of Cl, or of vapours of Br. On the other hand, Cl cannot exist simultaneously with cyanogen, carbonic oxyde, ammonia, and in fact it decomposes almost all the gases which contain hydrogen, especially under the influence of solar light, or even of a powerful artificial light.

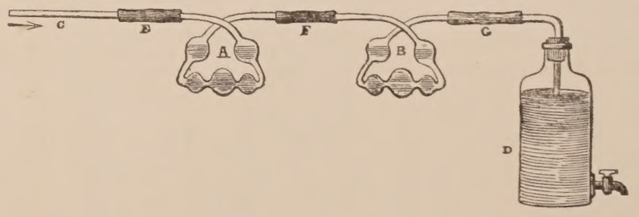
k. In presence of water Cl decomposes SO_2; HS and SO_2 decompose each other, a production of water and a deposit of sulphur taking place; and Cy cannot exist with HS nor with Cl, nor with NH_3. We have already alluded to these various reactions in some of the Observations in the Preliminary Tables.

l. It is evident also that for all the gases which are pretty largely soluble in solution of potash, or in water, that these solutions may be identified by their behaviour with reagents, or in other words, the solution of the gas may be analyzed as directed in the preceding Tables; namely, as if it were simply a solution of hydriodic, hydrobromic, carbonic acids, &c., or solutions of bromides, iodides, carbonates, &c.

m. If the quantity of gas is not too considerable, or if the operator possesses a mercurial trough large enough, and if the mixture is one of gases some of which may be absorbed by potash, he may at once remove such gases from the whole mass in the following manner: Take a suitable tube closed at one end, and put into it a sufficient quantity of sticks of potash, moisten them with water, and close the mouth of the tube with a piece of kid glove. The potash tube being thus prepared, tie it to a wire of annealed iron, and pass it through the mercury into the gaseous mixture, and leave it there for a suitable time, ten or twenty hours, until, in fact, all absorption has ceased. Remove then the tube containing the potash, by means of the iron-wire to which it is attached, and analyze the residuary gas as directed in Table XXXIV.—B. From the number of divisions occupied by the gaseous mixture before and after the experiment, it is evident that the operator is enabled to determine quantitatively the amount of gas which has thus been absorbed by the KO.

n. If the quantity of gas is considerable, such as the atmosphere for example, and if it be desired to detect a gas such as carbonic acid, or sulphurous acid for example, or sulphuretted hydrogen, the gas or atmosphere to be examined is made to traverse an apparatus containing liquids capable of absorbing and arresting some of the gases which are the object of research, whilst the others are collected in another part of the apparatus.

Let us suppose, for example, that it is wished to determine whether carbonic acid and sulphurous acid, or carbonic acid and sulphuretted hydrogen, exist in common air:—Fill first the bulbs A



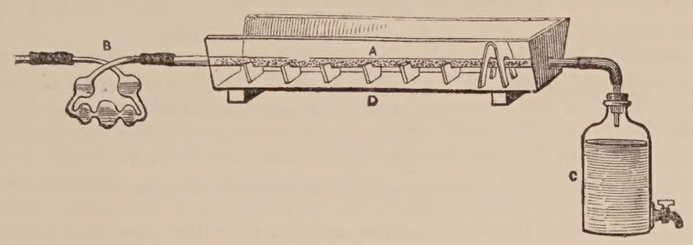
with solution of acetate of lead strongly acidified with $\bar{A}$,HO, and the bulbs B with a solution of caustic potash, connect them together, with the glass tube C, and with the bottle D (previously filled with water) by means of small tubes of vulcanized india rubber, E, F, G. If the tubes of caoutchouc are sufficiently narrow to take a good grip of the tubes, no ligatures will be required, provided there be not much pressure. If no vulcanized india rubber is at hand ordinary sheet caoutchouc may of course be used. On opening carefully the tap of the bottle D the water contained therein will of course flow out and produce a current of gas to pass along the whole apparatus; but if sulphurous acid, or sulphuretted hydrogen, and carbonic acid are present the two first will be arrested by the acetate of lead in the bulbs A, but the carbonic will continue its progress and be absorbed by the potash in the bulbs B, whilst the rest of the gases, which cannot be absorbed by the liquids in the bulbs, will pass on and eventually fill the capacity of the bottle D in the room of the water which will have flowed out.

o. If the object were at the same time to remove the aqueous vapour mixed with the gases, this may be easily done by causing the gas to traverse a flask of concentrated sulphuric acid before entering the bulbs, which flask of concentrated sulphuric acid may be replaced by one or two U-shaped tubes filled with pumice stone moistened with concentrated sulphuric acid, or filled with chloride of calcium—which tubes if weighed before and after the experiment will, of course, indicate by the increase of weight the quantity of moisture which will have been absorbed.

p. When carbonic acid, oxygen, and nitrogen have to be separated from each other, the following apparatus may be used:—

A is a tube of German glass containing clean copper turnings; B, the bulbs containing a solution of caustic potash; C, the bottle full of water provided with a tap; D, a combustion-tube furnace. The combustion tube is first made red hot, and after a few minutes the air contained in the apparatus having been expelled, the bottle C is connected with one end of the tube, and on the tap being gently opened the gas to be examined enters in B, where the CO_2 is arrested, thence through the red-hot tube A, full of clean copper turnings, which deprive it of its oxygen, and finally the bottle C becomes filled with the nitrogen which was supposed to exist in the gaseous mixture. The gaseous mixture

should, however, be deprived of aqueous moisture by causing it to pass through one or two bottles containing concentrated sulphuric acid as mentioned before, and the copper turnings should be first heated to redness in a current of hydrogen in order to have them perfectly clean.



Group 6 *to* 12.

q. Take care to use enough lime water, for if an excess of CO_2 be present the milkiness, or precipitate at first produced will disappear, since CaO,CO_2, is soluble in excess of CO_2

Group 8 *to* 10

r. HS—SeH—TeH may also be distinguished by mixing them with water, and leaving the whole at rest; under these circumstances, HS produces a deposit of sulphur which renders the water milky or yellowish; SeH one of selenium of a red colour, and TeH one of tellurium of a brown colour and metallic lustre.

s. (Col. 11.) We have already said above that NH_3 cannot exist in presence of free acids, of chlorine, &c., and although potash evolves an odour of NH_3 when triturated or mixed with an ammoniacal salt, yet when a solution of potash is mixed or agitated with ammoniacal gas there is always a certain amount of absorption produced, however concentrated that solution may be; the odour of the gas, however, is quite characteristic.

t. (Col. 13.) The precipitate produced when AgO, NO_5 is added to the KO solution of the gas previously supersaturated with NO_5 is, of course, indicative of the presence of Cl only after proof of the absence of HCl; the latter substance, however, is readily distinguished by its different odour, by its much superior solubility in water, by the acidity of its solution, and therefore by its reddening instead of bleaching litmus.

Systematic Analysis of a gas which cannot be absorbed by a solution of KO, or of the residue which was left unabsorbed thereby, and alluded to in TABLE XXXIII., Col. 13.

The GAS is NOT A MIXTURE of GASES.

It may be H—C_2H_4—C_4H_4—NH_3—PhH_3—AsH_3—SbH_3—O—CO—NO_2—NO—N. Take a portion of the gas in an ordinary gas test-tube and present a lighted taper at its orifice (Observation *a*, *b*).

The Gas BURNS.

Presence of H—C_2H_4—C_4H_4—PhH_3—(Observation *b*.)—AsH_3—SbH_3—NH_3—CO. If the flame of the burning gas is

1	2	3	4	5	6	7	8
Thin, bluish inodorous, or almost so.	Thin and bluish yellow with a peculiar somewhat empyreumatic odour.	Yellow-white very luminous, somewhat empyreumatic and ethereous odour.	Yellow accompanied by white and very acid fumes.	Thick and white.		Blue.	Yellowish, Odour of NH_3.
H Agitate another portion of the gas with AgO,NO_5.	C_2H_4. Agitate another portion with AgO,NO_5.	C_4H_4. Agitate a portion of the gas with Br in a fountain tube, so that the hyacinth red vapour of bromine tinge the whole tube, add a little solution of KO, or a small bit of caustic KO, and agitate the whole.	PhH_3.	AsH_3—SbH_3.		CO. Transfer another portion of the gas to a bent gas test-tube through mercury, and heat a globule or more of potassium in the bent part of the tube.	NH_3. Observation *k*. The odour is quite characteristic.
O.	O.	Absorption.	Shake another portion of the gas with a solution of AgO,NO_5.			Absorption.	
Mix another portion of the gas with half its bulk of chlorine over water and IN THE DARK (Obser. *c*, *d*.), in a fountain tube and allow the mixture to stand over water in diffused daylight for fifteen or twenty hours.	Mix another portion of the gas with half its bulk of chlorine over water and IN THE DARK (Observ. *c*, *d*, *f*.) in a fountain tube, allow the mixture to stand over water in diffused daylight for fifteen or twenty hours.	See Observation for the mode of operating in TAB. XXXIV.—B. Col. 10.	Absorption accompanied with **Black Precipitate.** (Observation *g*—*i*.) Shake another portion of the gas with solution of corrosive sublimate (HgCl.)			CO. Observation *j*.	
Absorption.	Absorption.		**Yellow.**	**Brown.**	**White.**		
Add an excess of lime water and shake.	Add an excess of lime water and shake, absorption and		PhH_3. Observ. *h*, *i*.	AsH_3. Observ. *h*, *i*.	Sb,H_3. Observ. *h*, *i*.		
O.	Milkiness.						
H. Observation *f*.	C_2H_4. Observation *e*.						
H.	**C_2H_4.**	**C_4H_4.**	**PhH_3.**	**AsH_3.**	**SbH_3.**	**CO.**	**NH_3.**

The Gas does NOT BURN.

O—NO—NO_2—N—NH_3.
Introduce into another portion of gas contained in an ordinary gas test-tube a glowing splinter.

9	10	11	12	13
Rekindled.		Not rekindled.		
O—NO. Take another portion of the gas and introduce it into a tube containing a few bubbles of NO_2.		NO_2—N—NH_3. Take another portion of the gas and introduce it into a tube containing a few bubbles of air, or of O.		
Ruddy Fumes.	**O.**	**Ruddy Fumes.**	**NO Ruddy Fumes,** but immediately absorbed by HO.	**O.**
And absorption.	NO. This gas is soluble in half its bulk of HO.	NO_2. To another portion of the gas add solution of FeO,SO_3 and shake.	NH_3. Characteristic odour of NH_3.	N. This gas is not affected by any of the reagents mentioned, it is not combustible, neither can it support combustion.
O.		**Blackish colour.**		
		Accompanied by absorption.		
O.	**NO.**	**NO_2.**	**NH_3.**	**N.**
9	10	11	12	13

Is A MIXTURE.

Examine according to the direction given in TAB. XXXIV.—B.

14

OBSERVATIONS ON TABLE XXXIV.—A.

a. The inflamation of the gas had better be attempted somewhat in the dark, as for example, under the operating table, the aspect of the flame being thus much more distinct.

b. When PhH_3 has been prepared by boiling Ph with strongly alkaline solutions, it inflames spontaneously in contact with the air, but when obtained in any other way it does not inflame spontaneously but burns with a yellow flame, accompanied by thick white acid fumes when set fire to, a garlicky odour being at the same time observable.

Group 1 *to* 3.

c. (Cols. 1 and 2.) It is advisable before adding the chlorine to shake the gas with water in order to remove any NO which might be present, because this gas being soluble in half its own weight of water would prevent the absorption caused by Cl from being observed, or would cause it to be attributed wrongly to the presence of hydrogen, or of a hydrocarbon.

d. It is evident that if NH_3 is present it will be absorbed by the water used still more rapidly than NO, and the water will have the characteristic odour of NH_3, and have the power of restoring the blue colour of reddened litmus paper.

e. The milkiness produced with lime-water is due to the presence of carbonic acid, resulting from the decomposition of the light carburetted hydrogen in presence of Cl, and water, yielding $HCl + CO_2$, and sometimes a little CO. The amount of CO_2 absorbed is equal in bulk to the quantity of light carburetted hydrogen (C_2H_4) present.

f. As the mixture of hydrogen, or indeed of all the hydrocarbons with chlorine is very explosive, and this (in the case of hydrogen) spontaneously under the influence of the solar ray, it is advisable to effect the mixture in the dark, or in a part of the room where nothing but diffused light is admitted, and to cover the tube or jar with a cloth whilst the Cl is passed into it, for fear of accidents.

Group 4 *to* 6.

g. This black precipitate produced by AgO,NO_5 is metallic silver. *

h. The yellow, white, or brown precipitates produced by solution of corrosive sublimate (HgCl) are mixtures of corrosive sublimate, water, and phosphuret, or Arseniuret of mercury.

i. The above precipitates treated in the reduction tube with soda produce a metallic mirror, in which the presence of arsenic or antimony may be immediately recognised, the one being very volatile and emitting a characteristic odour of garlic when heated, the other being fixed and odourless.

Group 7.

j. (Col. 7.) CO behaves in every respect like C_2H_4 with reagents, except that its flame is more intensely blue, and that it is absorbed when treated with potassium.

Group 8.

k. (Col. 8.) NH_3 seldom burns in a visible manner, except it be present in somewhat large quantity. Yet, if a lighted match be brought in the dark near the mouth of the tube, which should be held vertically with the mouth upwards, a faint yellowish hallow may be seen round the lighted match, which hallow is due to the ammonia taking fire as it issues from the tube. As, however, this effect may escape notice as likely as not, and will altogether fail if the ammonia is mixed with other gases, we have included NH_3 under both heads, that is, among the number of gases which burn, and of those which do not burn in contact with the air. The odour of NH_3, however, is so pungent, its absorption by water so rapid, and its power of restoring the blue colour of red litmus paper are so characteristic and delicate that the presence of this gas cannot be overlooked.

---

* If the gas is AsH_3 its combustion will be accompanied by white fumes of AsO_3, and by an odour of garlic, while a brown deposit will take place in the glass tube.
If the gas is SbH_3 its combustion will produce white fumes also, but they consist of oxyde of antimony and a black deposit will be observed in the tube.

TABLE XXXIV.—B.

Systematic Analysis of a gaseous mixture which cannot be absorbed completely by a solution of KO, and alluded to in Col. 14, TABLE XXXIV.—A.

THE GAS IS A MIXTURE OF GASES.

Transfer a portion of the gaseous mixture to a strong gas test-tube, agitate it with some water, and observe whether an absorption has taken place, then present a lighted taper to the orifice of the tube.

The gas or gaseous mixture is NOT ABSORBED AT ALL or only PARTLY by solution of KO.

If the gas cannot be absorbed at all by a solution of KO, add to it a solution of AgO,NO_5. If the gas is partly absorbed by a solution of KO, remove all that which can be thus absorbed by introducing into the gas, or gaseous mixture, through mercury, and by means of an annealed iron wire a stick of caustic KO slightly moistened and leave it therein for about twelve or fifteen hours, or more, in fact, until all absorption has ceased (Observation *f.*), remove the stick of KO by means of the wire to which it is attached, and transfer the unabsorbed gas, or a suitable portion thereof to another gas test-tube, and by means of a bent pipette (Observation *d*, TABLE XXXIII.), pass into it a solution of AgO,NO_5.

If the water with which the gas has been agitated produced an absorption it may be due to the presence of NH_3, or or of NO, or of both. If the water smells of NH_3 and restores the blue colour of litmus-paper, NH_3 is of course present. **NO** will be detected in Col. 4, 16, 20.

Inflammation, or Detonation.

NO Inflammation NOR Detonation.

$H—C_2H_4$ C_4H_4— PhH_3—AsH_3 SbH_3—CO if detonation takes place it is a mixture of a hydrogenous compound with O or with atmospheric air, or with NO. (Obs. *a.*)

O—NO—NO_2—N.
Transfer another portion of the gaseous mixture to another gas test-tube, and introduce into it a glowing splinter.

Rekindled.	Not rekindled.
O—NO. Take another portion of the gaseous mixture and introduce into the tube containing it a few bubbles of NO_2.	NO_2—N. (Observation *b.*) Take another portion of the gaseous mixture and introduce into the tube containing it a few bubbles of O.
Ruddy Fumes. and absorption. **O.**	**Ruddy Fumes.** NO_2. Confirm by adding to another portion of the gas a solution of FeO,SO_3 and shake. **Greenish black colour.** NO_2.
O. This gas is absorbed by half its bulk of water.	**O.** N. This gas is not affected by any of the reagents mentioned and cannot support combustion.
NO.	N.

Absorbed completely by AgO,NO_5, (observ. *c.*)

and the absorption is accompanied by a

Black Precipitate.

Presence of PhH_3—AsH_3—SbH_3.
Pass a portion of the gaseous mixture through a German glass tube heated at one point by means of a spirit lamp, as in Marsh's apparatus.

Metallic mirror.	Deposit of phosphorus.
AsH_3—SbH_3. Heat the metallic mirror.	PhH_3. (Obs. *c, d.*)
Volatile.	Fixed.
Odour of garlic.	No odour of garlic.
AsH_3. (Obs. *c, e.*)	SbH_3. (Obs. *c.*)
AsH_3.	SbH_3.

NOT absorbed at ALL or only in Part by AgO,NO_5, (Observation *c, f.*)

$H.—C_2H_4—C_4H_4—CO-O—NO—NO_2—N.$

If the gaseous mixture has proved in the preceding experiments to be inflammable or detonating in contact with the air, presence of $H—C_2H_4—C_3H_4—CO$ alone or mixed together, or with $NO_2—N—NO$ or **O**. Detonation takes place only if O or atmospheric air is in sufficient quantity. (Observation *a*, and see col. 2.) Transfer the gas which has not been absorbed by the solution of AgO,NO_5 to a fountain tube over water and test with Br as described in Observations *h*, *i*.

Absorbed completely	NOT Absorbed at ALL or only in PART.
C_4H_4 only is present.	The part absorbed is nothing else than C_4H_4 or other heavy hydrocarbons. The unabsorbed portion is $C_2H_4—H—CO$ but possibly also O—NO—NO_2—N—Mix a portion of the unabsorbed gas with half its bulk of Cl in the dark (Observ. *i*), and allow the mixture to stand in a well-lighted room, but not exposed to the direct rays of the sun for several hours.

Absorption.	No Absorption.
To the gas which has been mixed with Cl and which has been left exposed to day-light, add an excess of lime water and shake.	(If a partial absorption has taken place the liquid in the tube must be examined as directed in Cols. 11, 12, 13.) N—NO—O alone, or mixed $N—NO_2$, NO alone or mixed—O—N alone or mixed. Observ. *g.* (The operator will recollect that NO is soluble in half its bulk of water.) To a portion of the unabsorbed gas add a few bubbles of NO_2 over water.
Absorption and MILKINESS.	Absorption NO MILKINESS.
C_2H_4—CO, either, or both (Obs. *j.*) Transfer another portion of the gaseous mixture not mixed with Cl to a bent test-tube over mercury, placing previously a piece of potassium in the bent part of the tube, and heat the potassium therein with a spirit-lamp as described at the beginning of the Observations, TABLE XXXIV.—A., and Observ. *k*, of this Table.	H.
NO Absorption.	Absorption.
C_2H_4.	CO.
C_2H_4.	CO.

Ruddy fumes and Absorption.	No Ruddy fumes.
O. Obs. *l.*	To another portion of the gas add a few bubbles of air or of O.
O.	**Ruddy fumes** and Absorption. Confirm with solution of FeO,SO_3 as in Col. 5.
NO_2.	NO. This gas is soluble in half its bulk of water.

N—NO either or both. Plunge an ignited or glowing splinter in the gas which has not been acted upon by either KO—AgO,NO_5—Br—Cl—O nor by NO_2. (Observ. *g.*)	
Supports combustion.	Does not support combustion.
NO. This gas is soluble in half its bulk of water.	N. (Observ. *m.*)
NO.	N.

If the gaseous mixture has proved uninflammable and did not detonate, presence of N—NO—NO_2—O, but possibly also the other gases alluded to in the preceding columns may be present but in too small quantity to produce inflammation or detonation, wherefore the gaseous mixture should be tested for those gases as directed in Cols. 10 to 17. (Observ. *g.*)

Treat now the gas which was not acted upon by any of the preceding reagents, or the residue left after such action as follows:—

To a portion of the gas add a few bubbles of NO_2 over water.	To another portion of the gas add a few bubbles of O, or of atmospheric air over water.	The gas which has not been acted by any of the preceding reagents, or which was left after such action, must be either NO or N. Plunge therefore a lighted taper into the mixture, or mix it with half its bulk of water, or of alcohol, and shake.
Ruddy fumes, and Absorption.	**Ruddy fumes.** Absorption.	Supports combustion. NO. (Observation *m.*) — Absorption. **O.** N. (Obs. *m.*)
O. (Obser. *l.*)	NO_2.	NO. — N.
O.	NO_2.	NO. — N.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

OBSERVATIONS ON TABLE XXXIV.—B.

a. (Col. 2.) If the operator has reason to think that C_4H_4 and O, or atmospheric air, are present, he had better wrap up in a cloth the glass tube containing the mixture; the detonation in that case being always extremely violent, and generally accompanied by the disruption of the vessel.

Groups 5 *and* 6.

b. If NO_2 be present, the gas in the tube will at once be tinged with ruddy fumes of hyponitric acid upon the air coming in contact with it.

Groups 7 *to* 9.

c. When PhH_3—AsH_3 or SbH_3 are present, there is always, or generally, a portion of gas left unabsorbed by the solution of AgO,NO_5, which unabsorbed portion is H; these gases almost always containing a certain amount of free H.

d. PhH_3 is sometimes spontaneously inflammable, as we have said already in the Observations on Col. 4. TABLE XXXIV.—A.; but, however prepared, it can always be ignited by presenting a lighted taper at the orifice of the vessel containing it, when it burns with a yellow flame, and with the production of white and extremely acid fumes, which are quite characteristic.

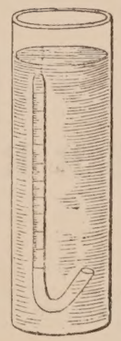
e. (Col. 7.) Arseniurretted hydrogen may always be easily recognised by submitting the metallic mirror to the usual tests for arsenic, to which the operator is referred.

Groups 10 *to* 21.

f. If the quantity of gas be considerable, and if the operator possesses a mercurial trough of sufficient dimensions, and if the gas be a mixture of gases, some of which are absorbable by KO, as will have been detected, TABLE XXXIII., he may at once remove such gases from the whole mass as follows:—Introduce into a tube closed at one end some sticks of caustic potash, moistened with water, and close the tube with a piece of kid glove. Fasten the tube so prepared to a wire of annealed iron, and push it through the mercury into the gaseous mixture, and leave it there for a suitable time—ten, fifteen, or twenty hours—until, in fact, all absorption has ceased, after which, the residuary gas may be examined according to the directions given in this Table. From the number of divisions occupied by the gaseous mixture before and after the experiment, it is evident that the operator may at once ascertain the amount of gas which has been absorbed by the KO.

g. Of course, O and NO_2 cannot exist simultaneously, since, in fact, they are tests of each other's presence, by the ruddy fumes produced when they come in contact.

h. The best way, perhaps, of operating with Br for the detection, and, in fact, determination, of the amount of C_4H_4 in a gaseous mixture, consists, first, in filling a fountain gas test-tube with water, and then transferring thereto as much of the gas or gaseous mixture as will fill the whole or any number of the divisions marked thereon. The tube is then immersed *completely* into a cistern, or larger tube, filled with water, as represented in the margin, and after leaving it there for a few minutes, so that the temperature of the gas may become uniform, it (the tube) is then raised up, so that the water inside, and that outside of the fountain tube, may stand at the same level, the exact number of divisions occupied by the gas may now be carefully noted, and the fountain tube being lifted quite out of the cistern, a drop of bromine is poured, by means of a straight pipette, into the elbow part of the fountain tube, the orifice of which is next to be closed *under water* with a good cork. The fountain tube, thus corked, is again lifted out of the water, and its contents are to be well shaken until the vapour of



bromine becoming diffused through the tube, the latter becomes tinged with the characteristic reddish-brown hue of bromine. The orifice of the corked fountain tube is then plunged under water, and whilst thus under water the cork is removed. If C_4H_4 be present, an absorption takes place. The fountain tube is then again lifted out of the water, a few drops of a strong solution of KO are poured into the elbow part of the tube, the orifice of which is again to be corked up under water. This done, the corked fountain tube is to be lifted out, and well shaken with the solution of KO, which has been added, so as completely to remove the vapours of bromine. The fountain tube is next to be uncorked *under water*, when a fresh absorption will take place. The fountain tube is to be completely immersed into the water of the cistern, and left there for a fewminutes, as at the beginning of the operation, in order to bring the gas again to a uniform temperature; after which, it (the tube) is drawn out, so that the surface of the water inside, and that of the water outside of the tube, may stand at the same level, when the number of divisions occupied by the gas should again be carefully noted. The difference between the first and the second reading indicates, of course, the amount of absorption, and consequently the amount of C_4H_4 present in the mixture.

i. If the gaseous matter not absorbed by AgO, NO_5, contains other gases besides C_4H_4, the whole of the mixture should be first treated by Br, in order to remove the latter gas completely; the unabsorbed residue may then be treated, as described in this TABLE, with Cl, &c., &c. In order to save time, the whole mnss of the gaseous mixture may be treated with Br, and solution of KO, in a vessel like that

represented in the margin, which, as may be seen, is nothing else than an enlarged fountain test-tube. To transfer the residuary gas from such a jar to any other vessel, the jar is to be immersed in water, the vessel to which the unabsorbed gas has to be transferred being previously filled with water, is then placed over the cock of the jar, so that on opening it the gas at once passes into the vessel above it.

The mixture with Cl should be made in the dark, for fear of spontaneous explosion. *See* Observ. on Col. 1, 2, 3, TABLE XXXIV.—A.

j. (Cols. 11 and 12.) The milkiness and absorption is due to the formation of CO_2, which has taken place as a result of the decomposition of the light carburetted hydrogen (C_2H_4), or of the carbonic oxide (CO), under the influence of the Cl and water, the first forming $HCl+CO_2$, whilst the second forms chloroxy-carbonic acid (CO,Cl), which, in contact with water, becomes decomposed, along with 1 equiv. of water, into $HCl+CO_2$ thus:—

$$CO,Cl + HO = CO_2 + HCl.$$

k. The operator will recollect that NO is also decomposed by K, but the decomposition is not attended with diminution of volume by treatment with potassium, as is the case with CO. The potassium combines with the oxygen of the protoxyde of nitrogen, and liberates its nitrogen, which occupies exactly the volume of the original NO, that is to say, 1 vol. of NO contains exactly 1 vol. of N + ½ vol. of O, the latter being absorbed by the potassium.

l. (Col. 14.) Oxygen may also be separated by means of phosphorus, yet the latter substance in the cold has no action on oxygen, either when *perfectly pure* or when mixed with olefiant gas.

m. (17 and 20.) If the gas, before being agitated with water, supported combustion, and can do so no longer after such agitation, it is clear that the mixture consisted of NO, and of N, the NO having been removed by the water, N alone was left.

ERRATA.

Page 2, col. 3, Alphabetical List, between lines 10 and 11 from the top, insert,

"C_4H_6As . . Cacodyle or acetyle of arsenic."

Page 2, col. 3, Alphabetical List, between lines 24 and 25 from the top, insert,

"ClO_3 . . . . Chlorous acid."

Page 2, col. 4, Alphabetical List, between lines 6 and 7 from the bottom, insert,

"CyO,HO . . . Cyanic acid.
Cy_2O_2,2HO . . Fulminic acid.
Cy_3O_3,3HO . . Cyanuric acid."

Page 3, col. 1, between lines 14 and 15 from the top, insert,

"$HCyS_2$ . . Hydrosulphocyanic acid."

Page 3, col. 3, between lines 10 and 11 from the bottom, insert,

"PhO_5,3HO . . Tribasic phosphoric acid.
PhO_5,2HO . . Pyrophosphoric or bibasic phosphoric acid."

Page 3, col. 4, between lines 6 and 7 from the top, insert,

"Sb_2O_3,KO,$\overline{T}$,HO . Tartrate of antimony and potash (tartar emetic)."

Page 6, to the list of *yellow or orange yellow* salts, add,

"Bichromates, Rhodium, Osmium."

To the list of *greenish yellow or green salts*, add,

"Manganates—Molybdenum—Uranium (protoxyde)."

To the list of *blue salts*, add,

"Vanadium."

To the list of *red or reddish salts*, add,

"Molybdenum—Permanganates—Uranium (peroxyde)."

To the list of *brown or reddish brown salts*, add,

"Iridium—Osmium—Molybdenum—Copper (protochloride)—Palladium—Manganese (bi-oxyde)."

Table XXVI.—B., col. 16, line 5from top, instead of "have been found," read "have not been found."

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AND OTHER APPARATUS.

Fig.		£	s.	d.
1.	Galvanised Iron Pillar, with 3 Sliding Rings and set of Screws, 12 inches high, 4*s.* 6*d.*; 16 inches, 6*s.* 6*d.*; 20 inches	0	8	6
2.	Stronger and heavier ditto, with 4 Sliding Rings	0	12	0
3.	Small size, consisting of a brass Pillar and Sliding Rings for the Spirit Lamp, 3*s.* 6*d.* to	0	6	6
4.	Improved form of Sliding Rings recommended by Dr. Normandy. Holder and 3 rings 5*s.* 6*d.* to	0	7	6
5.	Berzelius's Stand and Supports for arranging tube apparatus, consisting of an adjusting brass pillar and iron foot, with table *b*, and supports *c* and *d* 5*s.* 6*d.* and	0	8	6
	Similar Stands in wood	0	3	6
6.	Improved Universal Spring Holder or Clip, for the support of Retorts and other apparatus (*e*) 3*s.* 6*d.* to	0	7	6
	Small ditto, for Test Tubes	0	2	6
	Iron Stand and Diminishing Rings for the support of Evaporating Dishes, Receivers, &c.	0	3	6
7.	Test Tube Stands or Racks for holding 6 tubes, 10*d.* to 2*s.*; 8 tubes, 1*s.* to	0	3	0
8.	Ditto, ditto „ 16 tubes	0	5	0
9.	Ditto ditto „ 8 tubes and draining pegs	0	3	0
	Ditto ditto „ 12 „ „	0	4	0
10.	Test Tube Box, as recommended by Dr. Normandy. These are in pairs, one to contain the clean tubes, placed mouth downwards, so that they may remain clean; the other to contain the tubes which have been used, and placed therein mouth upwards per pair 7*s.* 6*d.* to	0	12	0
11.	Test Tube Holders	0	0	9
12.	Watch-glass Holders	0	0	9
	Iron Tripod Stands, for support of Receivers, &c. 6*d.* to	0	1	0
13.	Taylor's Simple Support, for Platina Crucible, consisting of a triangular form of 3 pieces of tobacco-pipe fixed together by an iron wire running through them	0	0	6
14.	Simple form of Tube Holder	0	0	4

SOURCES OF HEAT.

LAMPS.—OIL.

15.	Argand Oil Lamp, No. 1 8*s.* 6*d.* to	0	12	6
	This Lamp is commonly used for heating Flasks, Retorts, &c., and requires the best Sperm Oil.			
c. 6.	Fountain Argand Lamp, adapted to slide on the Pillar of a Retort Stand	0	16	0

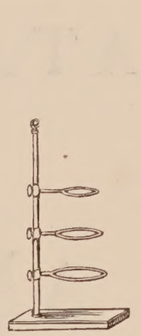


Fig. 1.

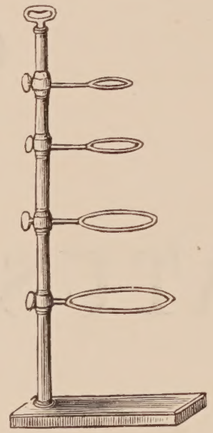


Fig. 2.

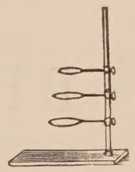
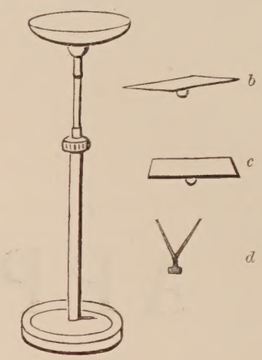


Fig. 3.

Fig. 4.



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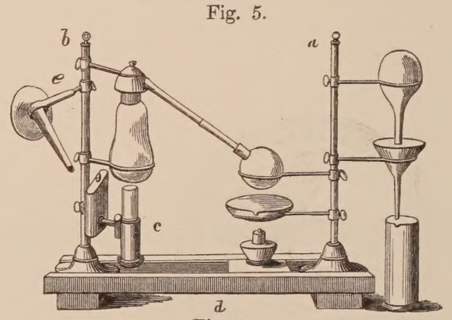
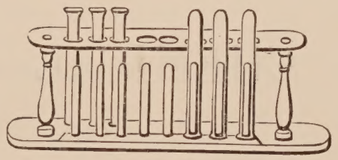


Fig. 6.



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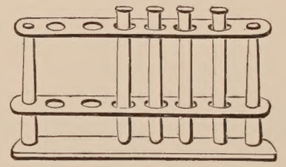


Fig. 7.

Fig. 11.

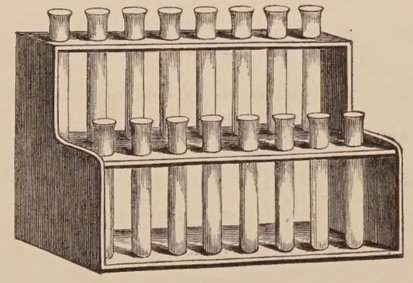


Fig. 8.

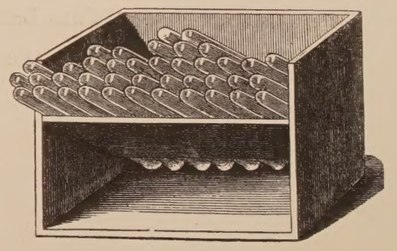
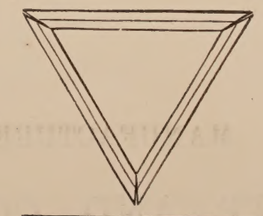


Fig. 10.



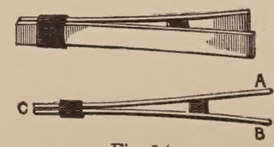


Fig. 14.

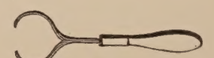


Fig. 12.

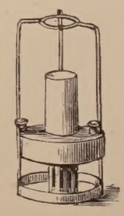


Fig. 15.

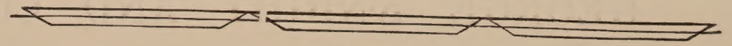


Fig. 13.

LAMPS.—SPIRIT.

Fig.		£	s.	d.
16.	Glass Spirit Lamp, with brass wick-holder and ground glass cap :— Capacity, ½oz., 1 oz., 2 oz., 4 oz., 6 oz., Price 2*s.*, 2*s.* 6*d*, 3*s.* 6*d.*, 4*s.* 6*d.*, 5*s.* 6*d.*			
17.	Small Brass Spirit Lamp, with Screw Cap . . . . . No. 1, 3*s.*, No. 2	0	3	6
18.	Brass Spirit Lamp, with Pillar and 2 Sliding Rings, for the support of watch-glasses, No 1, 5*s.*, No. 2	0	6	0
19.	Argand Spirit Lamp	0	12	0
	The body of this Lamp is made in japanned iron, the wick-holder of brass, with sliding wire for the support of Evaporating Dishes, Crucibles, &c.			
	Similar Lamp, made in copper	0	17	6
20.	Ditto sliding on a pillar	1	8	0
21.	Knight's Improved Assay Lamp	2	12	6
	Is made of copper, well tinned inside. The body is protected from the influence of heat by means of a Jacket made of soft wood and cork, which surrounds it—the spirit being kept perfectly cool during the longest operation. By aid of this Lamp a rapid and intense heat is produced, which suffices for analysis with a platina crucible. In the process of evaporation, sublimation, digestion, &c., the necessity of lighting a furnace is frequently dispensed with, as it is capable of heating a sand bath of considerable dimensions. The fuel used is pyroligneous or wood spirit, which in burning does not emit or deposit carbonaceous matter.			
22.	Russian Spirit Lamp, or Furnace . . . . . 9*s.* 6*d.* to	0	15	0
	By means of which a most intense heat can be obtained in a few minutes. It consists of a double cylinder of strong brass, the outer one being closed top and bottom, the inner one at the bottom only. A small tube, terminating in a jet, passes from the external to the interior chamber, rising nearly to the top of the former. The fuel—pyroligneous spirits, or spirits of wine—is supplied through an aperture at the side, and a further quantity is placed in the interior cylinder. This latter when ignited heats the portion confined in the outer cylinder. The pressure of the vapour forces the spirit through the jet in a stream, which ignited forms a powerful blow-pipe. So great is the heat produced that a platina crucible on the support speedily becomes heated to whiteness. It is instantaneously extinguished by placing on the cover.			
22 *a.*	Blow-pipe Lamp, with large wick, for bending or working glass tubes . 4*s.* to	0	7	0
	Wire-Gauze Chimneys, for Lamps	0	2	0
	They present the triple advantages of not being liable to be broken, of allowing the state of the flame to be at all times seen, and of being readily removed, as they always remain cool enough to be handled.			

LAMPS.—GAS.

Whenever the Chemist can command the use of gas it will be found the most ready, convenient, and economical source of heat.

23.	Gas Lamp Furnace . . . . . 8*s.* 6*d.* to	0	12	6
	This consists of a heavy brass or iron foot, with stop-cock, union screw, jet, and three feet of flexible tube.			
	Ring Burner, B . . . . . 4*s.* 6*d.* to	0	5	6
	Copper Chimney, with wire gauze, C . . . . . 4*s.* 6*d.* to	0	5	6
	Iron Jacket, or Furnace, for the support of Flasks, &c., D . . . . 4*s.* 6*d.* to	0	8	6
	Set of Light Iron Rings, for the support of smaller vessels on the top of the Iron Jacket, E . . . . . 2*s.* to	0	4	0
	The above forms a very convenient arrangement for applying gas as a source of heat.			

Fig.		£	s.	d.
24.	Gas Lamp Furnace, consisting of an iron Foot, Stop-Cock, and Ring Burner, with Iron Chimney, mounted with wire gauze . . . . . 4*s.* 6*d.* to	0	8	6
25.	Dr. Normandy's Gas Furnace	0	15	0
	This apparatus will be found to possess advantages over most others ; it is very convenient for analysis, for fusing and igniting substances, bending glass tubes, soldering metals, and indeed for all purposes where either a moderate or intense heat is required. It consists, as shown in the above figures, of two copper cylinders, one rather smaller than the other, the former being placed above the latter ; they are divided by a wire-gauge diaphragm. When in use it is readily supported on the ring of a retort stand, by means of three projecting arms, and placed over the orifice or stop-cock of a common gas burner ; on igniting the gas issuing from the apparatus a clear heating flame is produced, free from smoke, the whole of the upper cylinder being filled with a mixture of gas and atmospheric air. The orifice of the instrument is lined with a ring of black lead ware which effectually keeps the apparatus cool. When a more intense heat is required, a blast of air is sent into the centre of the flame, by means of the flexible tube and brass pipe (shown in the second figure), either from the mouth, a pair of bellows, or any other contrivance ; a flame is thus produced of great intensity, admirably adapted to the various purposes both of the laboratory and of the workshop.			

Fig. 16.

Fig. 17.

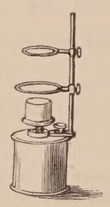


Fig. 18.

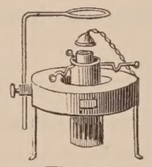


Fig. 19.

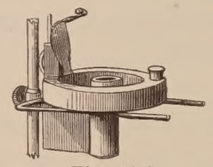


Fig. 20.

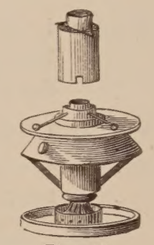


Fig. 21.

Fig. 22.

Fig. 22 *a.*

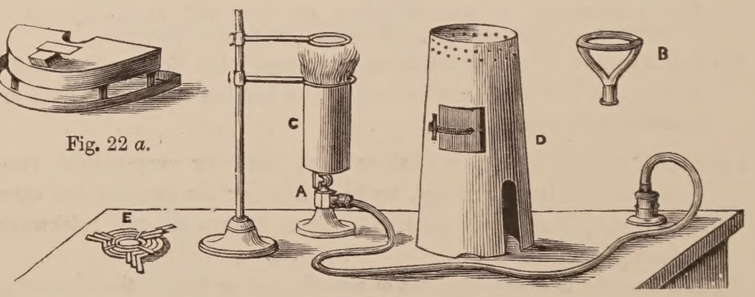


Fig. 23.

Fig. 24.

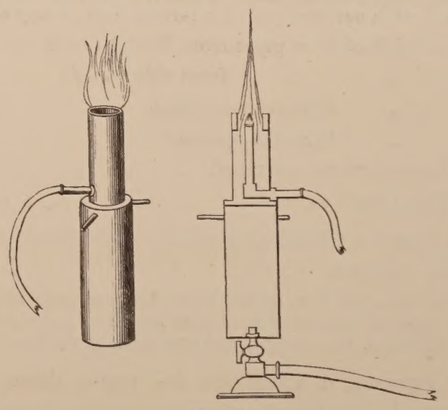


Fig. 25.

Fig.		£	s.	d.
26 A. & B.	Dr. Normandy's Improved Modification of the above Gas Furnace . . .	1	5	0

This differs from the one just described, viz. : The mixture of air and gas is much more intimate and the heat produced is accordingly more intense. It consists, as shown in the figure, of a wire-gauze cylinder partly cased in sheet iron in communication at the lower part with the atmospheric air, and closed at the upper part by a diaphragm of wire gauze provided with a short, slightly conical cover perforated in the centre. A blow-pipe jet placed outside the cylinder traverses the diaphragm and opens on a level with the aperture of the cover. The stream of cold air which is constantly rushing through the meshes of the wire gauze always keeps the body of the furnace in a cool state, so that it can at any moment be handled as if it were not lighted.

27. Arrangement for keeping up a stream of air through the Gas Lamp by means of an Indian-rubber Bag and Weight . . . . . .

FURNACES.

29*a. b. c. d.*	Knight's Portable Universal Chemical Furnace, on the principle of Dr. Black, with 3 feet of Iron Chimney, cast-iron Sand Pot, Cover, Muffle, and fire-clay Stoppers	6	0	0
29*e.*	Iron Stand, for raising the Furnace from the ground, with Shelf for Tongs . . .	0	17	0
29*f.*	Copper Still and Worm Tub, adapted to the Furnace	4	4	0

This form of Chemical Furnace has been found by experience to be the most useful for the experimentalist. It is constructed of stout sheet iron, lined with fire-bricks, and being fixed on castors, can be removed with ease, and adapted to any fire-place.

30.	Circular Chemical Furnace . . . . . 3*l.* 3*s.* to	5	5	0

This is constructed of stout sheet iron, and lined with fire-bricks, with cover, muffle, stoppers, and deep sand pot, well adapted for chemical purposes.

Smaller Furnace of the same form, but lined with fire-clay. Useful for making oxygen gas in a small cast-iron retort, for heating small crucibles, and for other operations on a small scale 2 2 0

31.	Cast-iron Plate, with Square Shallow Sand Bath for evaporation; two deep Sand Pots; set of Circular Rings, for increasing or diminishing the aperture; cast-iron Doors, Bars, and Stays. Complete fittings for the brickwork of a fixed Laboratory Stove	5	5	0

This is similar in construction, but of a smaller size to those in the laboratories of the Royal Institution and King's College. Besides the special purpose for which it is intended, it will supply an abundance of heat for warming the apartment in which it may be placed, and when not employed as a furnace forms a very convenient table.

	Length of iron plate from front to back . . . 3 ft.			
	„ „ from side to side . . . . 2 ft. 9 in.			
	„ Square Sand Bath . . . . . 21 in. by 14 in.			
	„ Circular opening . . . . . 8 in.			
	Iron-work as described	5	5	0
	Hot Closet extra	3	3	0
32.	Luhme's Portable Chemical Furnace, with Head, Shallow Sand Bath, and Retort Jacket, complete	5	5	0

This Furnace, the form of which was first suggested by Luhme of Berlin, is very useful, and is made of sheet iron, lined with fire-clay : perhaps its principal advantage is the readiness with which the draught, and consequently the heat, is regulated.

33.	Chemical Furnace, in which the flue passes through the Sand Bath, with fire-clay lining, well suited for heating evaporating dishes, small flasks, &c.	3	13	6

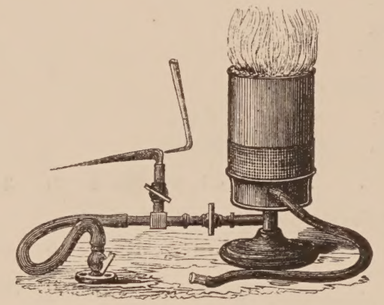


Fig. 26 A.

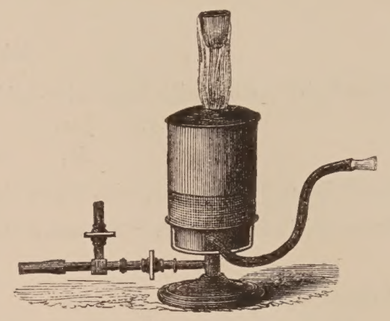


Fig. 26 B.

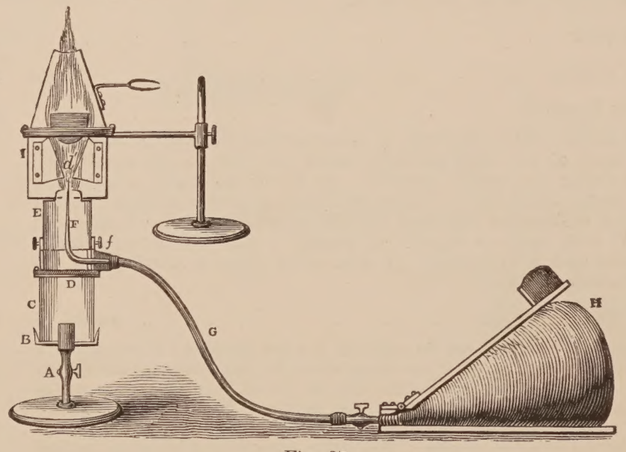


Fig. 27.

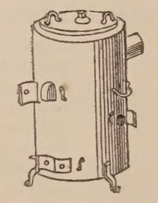
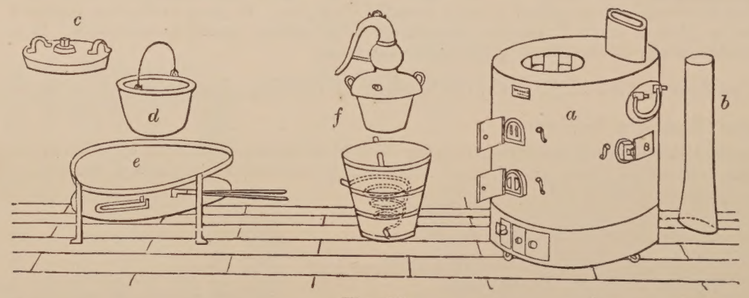


Fig. 30.



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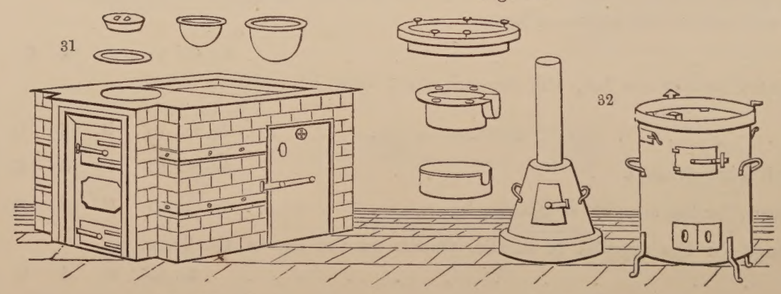


Fig. 31. Fig. 32.

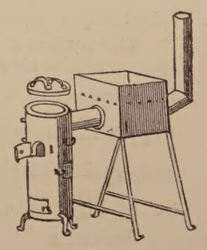


Fig. 33.

CHAUFFERS.

Fig.		£	s.	d.
	The Chauffer, or Charcoal Stove, will be found a convenient source of obtaining a ready heat, the fuel used being charcoal.			
34.	Wrought-Iron Chauffer, with Head, and 3 feet of Chimney Pipe, Tongs, and Charcoal Forceps	0	12	0
	This form, recommended by Dr. Read, for general purposes is 6½ in. deep and 6 in. diameter, with a grating of short bars. The Chimney is used for more readily kindling the fire and raising a high temperature.			
35.	Cast-Iron Chauffer. No. 1, 8 in. diameter	0	4	0
36.	Ditto ditto No. 2, 9 in. diameter	0	4	6
37.	Square Wrought-Iron Chauffers. 6 in. square, 2*s.* 6*d.*; 7 do., 3*s.*; 8 do., 3*s.* 6*d.*; 9 do., 4*s.* 6*d.*; 10 do., 6*s.* 6*d.*			
38.	Chauffer, or Sand Pot Surface. The upper part of this is formed of black-lead pot, the lower or ash-pit, of sheet iron, with cast-iron Sand Pot . . . 15*s.* to	1	1	0

BLACK-LEAD FURNACES.

39.	1. Of English ware. No. 1, 27*s.*; 2, 24*s.*; 3, 22*s.*; 4, 20*s.*; 5, 15*s.*; 6, 12*s.*			
	These Furnaces require greater care than those made from foreign black-lead pots, being more liable to crack from sudden change of temperature, but they are cheaper, and if carefully used answer very well.			
40 & 41.	French form of Furnace, made in fire-clay . . . . . 7*s.* 6*d.* to	2	2	0
	This form of Furnace is much used on the Continent.			
42.	Faraday's Furnace, with round Iron Grate, and 6 fire-clay Stoppers. Size of Crucible, No. 50, 15*s.*; No. 60, 20*s.*			
	This is a very useful furnace for general purposes. The draught is regulated by means of the stoppers.			
43.	Aikin's Blast Furnace, made of Black-Lead Crucibles. These Furnaces consist of three pieces, the foot, the furnace, and the open top. Size of Crucibles, No. 25, 1*l.* 1*s.*; 30, 1*l.* 5*s.*; 35, 1*l.* 10*s.*; 40, 1*l.* 15*s.*			
	To obtain a sudden heat, and to raise it rapidly to the greatest intensity, nothing is better than these furnaces. The furnace is composed of three parts—the lower one is the blast chamber; above this is the body of the furnace, perforated to admit the blast; and in the centre is the stand for the Crucible. The upper part, which is conical, concentrates the heat, causes it to reverberate on the bodies exposed to it, and protects the eyes of the operator from the glare of the fire.			
44.	Double Blast Bellows, on Stool, with Conducting Pipe and Nozzle	1	11	6
	The Bellows without Stool and Pipe	1	1	0
45.	Clark's Blower. This is a very useful machine for obtaining an abundant supply of air, though a strong blast cannot be obtained from it	0	7	6
46.	Transparent Screen. This Screen enables the operator to look into the hottest furnace without inconvenience	0	5	0

CRUCIBLES.

These are vessels constructed to receive substances which are to be submitted to a high degree of temperature; they are made of various forms and materials, and adapted to a great variety of circumstances.

Fig.

47. Black-Lead Crucibles, German Manufacture :—

No.	Height.	Price.	No.	Height.	Price.
	In.	s. d.		In.	s. d.
1	3	0 2	16	9	2 6
2	3½	0 3	18	9½	2 9
3	4	0 4½	20	10	3 0
4	5	0 6	25	10½	3 9
5	5½	0 7½	30	11	4 6
6	6	0 9	35	11½	5 6
7	6½	0 10½	40	12½	6 6
8	6¾	1 0	50	12½	8 6
9	7	1 1½	60	13	10 0
10	7¼	1 3	70	13½	12 0
12	7½	1 6	80	14½	15 0
14	8	2 0	90	15	18 0
15	8½	2 3	100	16	21 0

These Crucibles are formed of clay and plumbago, stand a very high degree of temperature, and do not generally crack on cooling, and the same Crucible can be used several times. The inside is smooth, so that melted matters do not adhere to them when poured out. They are much used for melting gold and other metals which require a great heat to fuse them, but are unfit for alkaline or saline matters; and, as they contain iron and charcoal, will not do for the purposes of the laboratory, where these substances would be injurious.

Fig. 34.

Fig. 35.

Fig. 36.

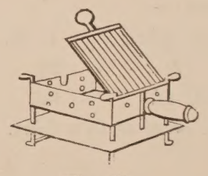
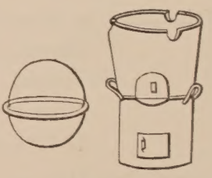


Fig. 37.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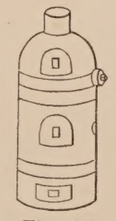
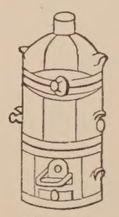


Fig. 39.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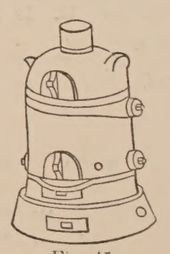


Fig. 41.

Fig. 42.

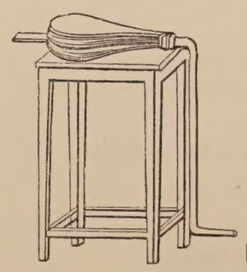


Fig. 44.

Fig. 43.

Fig. 45.

Fig. 46.

Fig. 47.

FIG. £ s. d.

48. HESSIAN CRUCIBLES, of triangular or three-square form, in nests :—

	Height of Largest Crucible.	Capacity of ditto.	Price per Nest. s. d.
Threes	3 in.	2 oz.	0 4
Small Fives	3½ in.	6 oz.	0 6
Large Fives	4½ in.	12 oz.	0 8
Sixes	5½ in.	1 pint.	1 6
Eights	6½ in.	1¾ pint.	2 0

The Hessian Crucibles are among the most valuable for general use, are always of the triangular form, and sold in nests of the sizes given above.

49. CORNISH CRUCIBLES. Round Assay Crucibles, two in a nest . . . per nest 0 0 4

49 *a*. Round form, three in a nest, with lips . . . . . per nest 0 0 6

Triangular, or 3-square, five in a nest, of the same size as the large five Hessian per nest 0 0 9

The Cornish, like the Hessian, is a most valuable Crucible in the laboratory, and, perhaps of the two, will stand the higher temperature.

LONDON CRUCIBLES. These are made principally of Stourbridge Clay, and for the generality of purposes answer as well as the Hessian and Cornish. Having the advantage of being made close at hand, they can be readily obtained of almost any form required.

50. Triangular, or three-square :—

Name	½ in.	1 in.	2 in.	3 in.	4 in.
Height	2	2½	3	3½	4¼
Price per doz.	4*d*.	6*d*.	8*d*.	1*s*.	1*s*. 9*d*.

Covers, same price as Crucibles.

51. Round Crucibles :—

Height	3 in.,	4,	5,	6,	7,	8,	9,	10,	11,	12,	13,	14,	15,	16 in.
Price, each	1½*d*.	2*d*.	2½*d*.	3*d*.	4*d*.	5*d*.	1*s*.	1*s*. 6*d*.	1*s*. 8*d*.	2*s*. 3*d*.				

Price of Covers, same as Crucibles.

51 *a*. Crucible Stands, from ½*d*. to 8*d*.

52. Skittle Pots or Crucibles ;—

Height. In.	Price. d.	Height. In.	Price. s. d.	Height. In.	Price. s. d.
3 ...	1½	8 ...	0 5	13 ...	1 2
4 ...	2	9 ...	0 6	14 ...	1 6
5 ...	2½	10 ...	0 8	15 ...	1 9
6 ...	3	11 ...	0 10	16 ...	2 3
7 ...	4	12 ...	1 1		

For many operations, especially in the Arts, as glass-making on a small scale, this is a very convenient kind of Crucible, for when the cover is removed, a comparatively small surface is exposed to the external air.

53. Subliming Pot, with Cover. Height, with Cover, 5 in., price 6*d*. ; 6 in., price 9*d*.

The substance to be heated is placed in the bottom portion, and the sublimed mass collects in the dome-shaped cover.

54. Enamelling Pot, with Cover. Diameter, 3½ in., price 7*d*. ; 4½ in., price 9*d*.

FIG. £ s. d.

55. Muffles, with open sides, used for assaying gold and silver, roasting ores, &c. Suited for Dr. Black's furnace . . . . . each 0 2 0

56. Cast-Iron Crucibles with Covers, turned bright.
Size 1½ in., 9*d*. 2 in., 1*s*. 3 in., 1*s*. 6*d*. Per nest of 3, with Covers . . . 0 3 0

57. Wrought-Iron Crucibles, with very thick bottom, for the assay of Galena . . 0 1 6
See Commercial Handbook of Chemical Analysis, by A. Normandy.

Pure Silver Crucibles :—Capacity, 1 oz.
" " 2 oz.

These Crucibles are used for the fusion of potash, soda, and for the preparation of caustic baryta from the nitrate, although for most operations they are superseded by platina.

58. Platina Crucibles and Covers. It is impossible to state the exact price of these, as it depends on the weight of the Crucible, the commercial price of Platina being subject to frequent variation. The Covers may be made to form convenient evaporating dishes.

Platina Crucibles being infusible at any heat, obtained either from the gas or spirit lamp, and resisting the action of chemical re-agents, renders them indispensable in many operations which without them could not be performed. They are, however, liable to be injured by various substances ; attention must therefore be paid not to use them improperly. See Preliminary Observations, page vii.

59. Case or Jacket, with Cover, made in fire-clay, for protecting a Platina Crucible when used in a furnace . . . . . from 6*d*. to 0 0 10

Platina Crucibles are liable to become rough at high furnace temperature. When exposed therefore to such influences, they should be inserted in an earthen case, and occasionally surrounded by a bed of magnesia.

60. Crucible Jacket of Sheet Iron, to be used over the spirit or gas lamp, for the purpose of confining the heat round the Platina Crucible 0 2 6

Fig. 48.

Fig. 49.

Fig. 49.

Fig. 50.

Fig. 51.

Fig. 52.

Fig. 53.

Fig. 51 *a*.

Fig. 54.

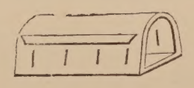


Fig. 55.

Fig. 56.

Fig. 57.

Fig. 58.

Fig. 59.

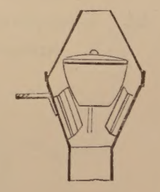


Fig. 60.

CRUCIBLE AND FURNACE TONGS.

These are required for placing crucibles in, and for removing them from the fire. The experimentalist will require an assortment of the various forms, according to circumstances.

Fig. | £ s. d.

61. Gilding Tongs: —

Length.	s.	d.	Length.	s.	d.
8 inches	1	2	18 inches	2	6
9 „	1	4	21 „	3	0
10 „	1	6	24 „	3	3
12 „	1	8	30 „	4	0
15 „	2	3			

62. Spring Bow Tongs, chiefly used for fuel:

Length,	12 in.	15 in.	18 in.	21 in.	24 in.	30 in.
Price,	6*d.*	8*d.*	10*d.*	1*s.*	1*s.* 4*d.*	2*s.*

63. Jointed Tongs for similar purposes:

Length,	12 in.	15 in.	18 in.	21 in.	24 in.	30 in.
Price,	9*d.*	1*s.*	1*s.* 3*d.*	1*s.* 6*d.*	2*s.*	2*s.* 6*d.*

64. Slight Crucible Tongs:

Length,	12 in.	15 in.	18 in.	21 in.	24 in.	27 in.	30 in.
Price,	8*d.*	10*d.*	1*s.*	1*s.* 3*d.*	1*s.* 6*d.*	1*s.* 9*d.*	2*s.* 3*d.*

Ditto, with the addition of a circular piece to clasp round the outside of the Crucible:

Length,	12 in.	15 in.	18 in.	21 in.	24 in.	27 in.	30 in.
Price,	8*d.*	10*d.*	1*s.*	1*s.* 3*d.*	1*s.* 6*d.*	1*s.* 9*d.*	2*s.* 3*d.*

66. Clip Crucible Tongs, measured across the top of the span or diameter of Crucible: 3 in., 1*s.* 6*d.*; 3½ in., 2*s.*; 4 in. 0 2 6

Very light Tongs, for handling platina and porcelain Crucibles, Evaporating Dishes, &c.: Black, 1*s.* 1*d.*; Bright 0 1 3

Ditto, larger, and of superior finish 0 3 0

Ditto, the ends tipped with platina 1 0 0

---

67. Light Furnace Pokers 0 1 0

68. Rakers for cleaning the bars of the furnace, from 1*s.* 6*d.* to 0 2 0

69. Small Shovels, 1*s.* to 0 2 0

29, fig. *d.* Cast-iron Sand Pots for portable furnaces: Inside diameter, 6 in., 2*s.* 6*d.*; 7 in., 3*s.* 6*d.*; 8½ in. 0 4 6

Cast-iron Rings, for diminishing the size of the top or mouth of furnaces; set of three 0 7 0

70. Knight's Improved Portable Sand Bath, with oil lamp complete 1 10 0

Ditto, without lamp 1 1 0

For operations on a small scale this will be found a very convenient apparatus; it is provided with a hot chamber for drying precipitates at a moderate temperature.

71. Copper Sand or Water Baths, with a series of different-sized rings to be used over a lamp 0 10 6

72. Portable Drying Ovens, or Closets: 6 in. high, 7 in. wide, 7 in. deep 1 10 0

Ditto ditto 8 in. „ 9 in. „ 9 in. „ 2 5 0

Ditto ditto 11 in. „ 12 in. „ 12 in. „ 5 5 0

These are constructed of sheet copper, and made double throughout, with the exception of the door. The space can be filled with water; it is provided with an opening into which a thermometer can be inserted. They are heated over a lamp, or on a sand bath.

Fig. | £ s. d.

Taylor's Hot Air Bath: size, 9 in. diameter, 5 in. deep, standing on three legs, 18*s.* to 2 0 0

This is an efficient apparatus which supersedes the oil-bath, as a temperature of 400° Fahr. can be kept up in it.

73. Apparatus for Evaporating Solutions to Dryness. (See Preliminary Observations, page vii.) . . . . . .

TESTING VESSELS AND APPARATUS.

TEST OR PRECIPITATING GLASSES.

These are of different forms and capacity.

Capacity.	Fig. 74.	Fig. 75.	Fig. 76.	Capacity.	Fig. 74.	Fig. 75.	Fig. 76.
1 oz.	6*d.*	6*d.*	6*d.*	4 oz.	9*d.*	1*s.*	1*s.*
2 „	7*d.*	7*d.*	7*d.*	8 „	1*s.*	1*s.* 2*d.*	1*s.* 2*d.*
3 „	7*d.*	7*d.*	7*d.*	11 „	1*s.* 6*d.*	1*s.* 9*d.*	1*s.* 9*d.*

Phillips' Precipitating Glasses, fig. 76,—this form is extremely convenient for allowing precipitates to subside.

Fig. 61.

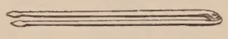


Fig. 63.

Fig. 64.

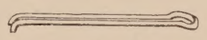
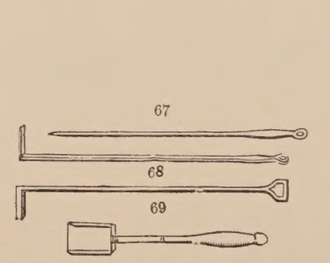


Fig. 62.

Fig. 66.



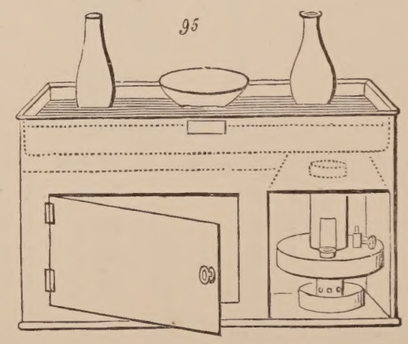


Fig. 70.

Fig. 71.

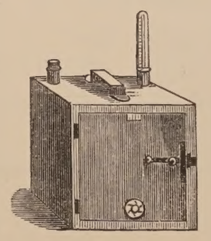


Fig. 72.

Fig. 75.

Fig. 76.

Fig. 74.

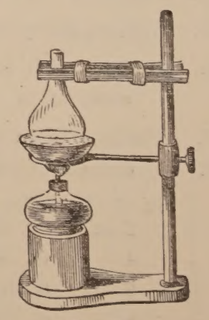


Fig. 73.

TEST TUBES.

Fig. | £ s. d.

These are made of hard German glass, well annealed, so that boiling hot liquids may be poured into them without their cracking.

	Length.	Diameter.	Per dozen.	Length.	Diameter.	Per dozen.
7.	2 inches	¼ inch	1*s.*	5 inches	⅝ inch	2*s.* 6*d.*
8.	3 „	⅜ „	1*s.* 6*d.*	6 „	¾ „	3*s.*
9.	4 „	½ „	2*s.*	7 „	1 „	4*s.* 6*d.*

Test Tube Racks and Holders (see p. 2) . . . . . .

77. Sulphuretted Hydrogen Apparatus 0 3 6
78. Normandy's Improved Sulphuretted Hydrogen Apparatus (see p. 28) . . . 0 10 6
Alkalimeters (see Graduated Glasses) . . . . . .

GLASS RETORTS AND RECEIVERS.

79 & 80

The Retorts of hard German glass :—

Capacity.	Plain. s. d.	Tubulated. s. d.	Stoppered. s. d.	Capacity.	Plain. s. d.	Tubulated. s. d.	Stoppered. s. d.
1 oz.	0 8	0 10	1 4	1 pint	2 0	2 3	3 0
2 „	0 8	0 10	1 4	1½ „	2 6	2 9	3 6
4 „	1 0	1 2	1 8	2 „	3 0	3 3	4 0
6 „	1 0	1 2	1 8	3 „	3 6	4 0	5 0
8 „	1 2	1 4	1 10	4 „	4 0	5 0	6 0
12 „	1 6	1 9	2 6	8 „	7 0	8 0	9 6

GLOBE RECEIVERS.

	Capacity.	Plain. s. d.	Stoppered s. d.	Quilled & Stoppered. s. d.	Capacity.	Plain. s. d.	Stoppered. s. d.	Qld. & Stpd. s. d.
81.	4 oz.	0 8	1 2	1 6	16 oz.	1 0	2 0	2 6
82.	6 „	0 8	1 4	1 9	24 „	1 3	2 6	3 3
&	8 „	0 9	1 4	1 9	32 „	1 9	2 9	4 6
83.	12 „	0 9	1 6	2 0	40 „	2 6	3 0	5 6

84. Adapters, required for connecting the retorts with the receivers, from 9*d.* to . . 0 3 0
85. Welters, safety tubes for preventing the bursting of retorts during the operation 1*s.* to 0 2 0
86. Funnels with long neck for conveying fluids into retorts without soiling the neck, 6*d.* to 0 1 9
87. Flasks of hard German glass, thin, and of uniform substance, so as to bear sudden
88. changes of temperature. Round and Flat Bottoms.

Fig. 87. Flat-bottomed.	Fig. 88. Round-bottomed.	Fig. 87. Flat-Bottomed.	Fig. 88. Round-Bottomed.
2 oz. 0*s.* 6*d.*	0*s.* 7*d.*	12 oz. 1*s.* 2*d.*	1*s.* 6*d.*
4 0 8	0 9	20 1 9	2 3
6 0 10	1 0	32 2 6	3 9
8 0 10	1 0		

Fig. | £ s. d.

Beaker Glasses of hard German glass, thin, and of uniform thickness, very useful for boiling solutions.

89. Set of six Beakers, with lip 0 5 0
90. 1. Set of three, containing from 2 oz. to 6 oz. 0 1 9
2. „ five „ 2 oz. to 14 oz. 0 2 9
3. „ eight „ 2 oz. to 4 pints 0 5 6
4. „ twelve „ 2 oz. to 9 pints 0 11 6
91. Filtering Funnels of ribbed glass.

Diameter,	1½ in.	2 in.	2½ in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.
Price,	3*d.*	4*d.*	5*d.*	6*d.*	8*d.*	10*d.*	1*s.* 2*d.*	1*s.* 9*d.*	2*s.* 6*d.*

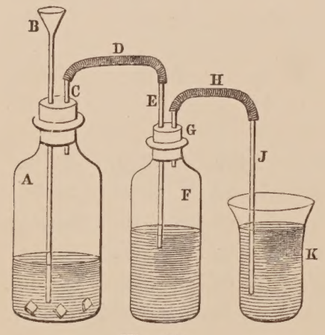


Fig. 77.

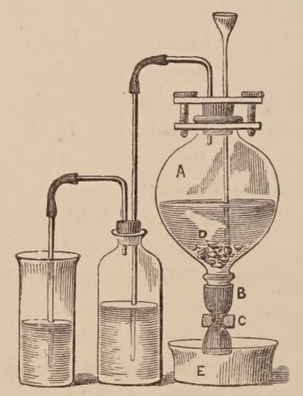
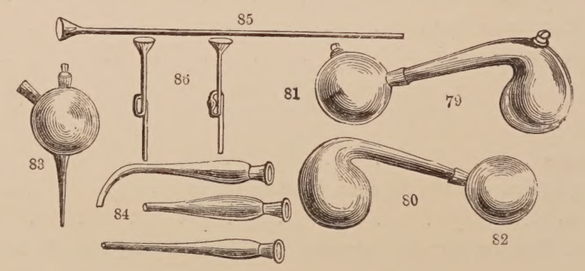


Fig. 78.



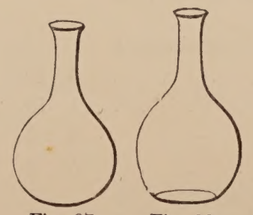


Fig. 87.

Fig. 88.

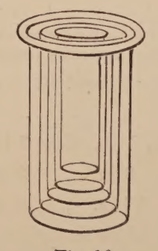


Fig. 90.

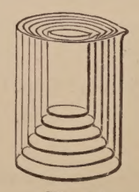


Fig. 89

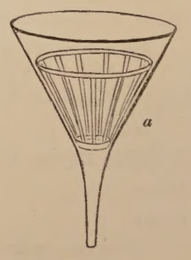


Fig. 91.

Fig.		£	s.	d.
	Filtering Funnels of Wedgewood Ware:			
	No. 1. 2. 3. 4. 5. 6. 7. 8.			
	Diameter, 2 in. 2½ in. 3½ in. 4½ in. 5 in. 6 in. 7 in. 8 in.			
	Price, 6*d*. 7*d*. 10*d*. 1*s*. 4*d*. 2*s*. 2*s*. 3*d*. 3*s*. 3*s*. 6*d*.			
	Glass Funnels fitted with a Tin Jacket containing water, which is kept hot by means of a spirit lamp	0	8	6
	By this contrivance fluids can be filtered at a high temperature.			
91 *a*.	Platina Wire Filter Support, £1 2*s*. 0*d*. to	2	2	0
	This being placed in a glass funnel, prevents the paper coming in contact with the sides, the filtration proceeding with increased rapidity.			
	Funnels fitted with a Glass Stop Cock, for separating fluids of different densities:			
	5 in. diameter, 9*s*.; 6 in. diameter	0	10	0
92.	Italian Recipients for similar purposes: 1 pint, 1*s*. 8*d*.; 2 pints, 2*s*. 8*d*.; 3 pints	0	3	4
93.	Pepys' Water Bath for drying Filters, adapted to be used on a retort stand	0	7	0
	This is a very useful contrivance for drying precipitates at a temperature never exceeding 212, hence it is especially adapted for explosive compounds.			
94.	A convenient arrangement to form an Oil or Water Bath, and very useful for drying small portions of soil for analysis			
95.	Small arrangement for testing weak solutions of Carbonic Acid	0	12	0
96.	Method of testing for Organic Matter			
97.	Arrangement for testing for Ammonia			
98.	Method of pouring a solution to be filtered into the funnel, and ensuring none of it being lost by running down the side of the beaker or glass			
99 *a*.	Bottle for washing Filters	0	1	6
99.	This cut shows the method of washing a Filter by aid of the bottle.			
100.	Method of rapidly filtering by causing a body of steam to issue from the mouth of a flask upon the filter.			

GRADUATED MEASURES.

101. These are made either Conical, with a foot,
102. Or Cylindrical, without foot.

Conical, 101.		Cylindrical, 102.
1 oz.	0*s*. 9*d*. each.	0*s*. 9*d*. each.
2 „	0 10 „	0 10 „
4 „	1 3 „	1 3 „
6 „	2 0 „	1 6 „
8 „	2 6 „	2 0 „
10 „	3 0 „	2 6 „
16 „	3 6 „	2 6 „
20 „	4 6 „	3 6 „

Drachm Measurer on foot, divided into 60 minims or drops 0 1 3

ALKALIMETERS, OR GRADUATED TUBES FOR SHOWING THE QUANTITY OF REAL ALKALI CONTAINED IN SODA, POTASH, &c.

101 A. B.	Normandy's Alkalimeter	0	10	0
102.	Gay Lussac's Alkalimeter	0	8	6

Fig. 92.

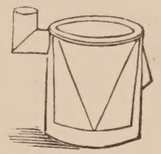


Fig. 93.

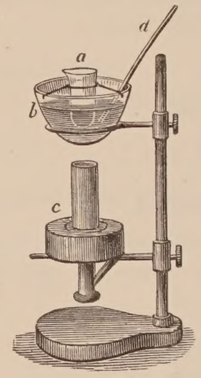


Fig. 94.

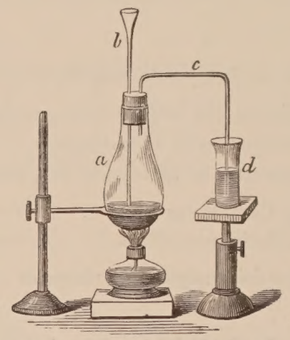


Fig. 95.

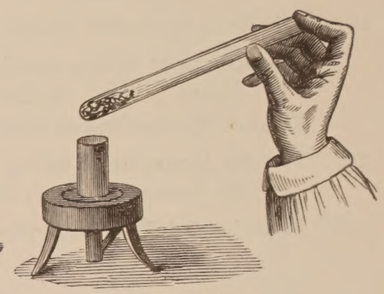


Fig. 96.

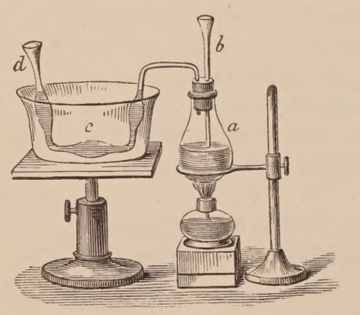


Fig. 97.

Fig. 98.

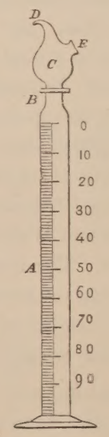


Fig. 101 A.

Fig. 101 B.

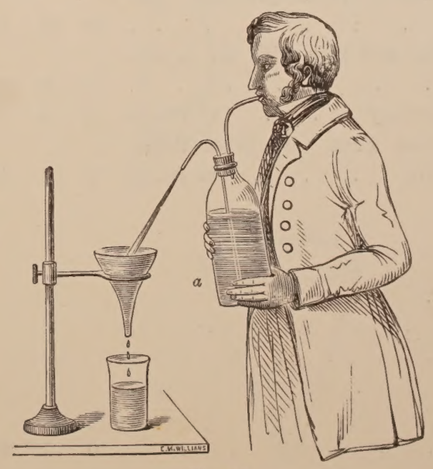


Fig. 99.

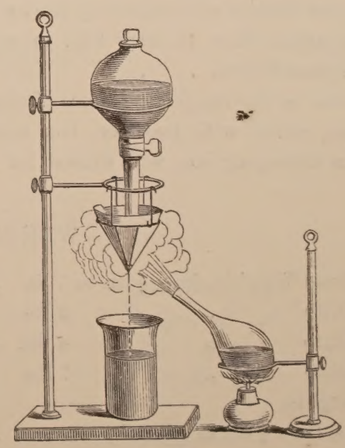


Fig. 100.

Fig. 101.

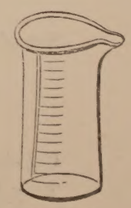


Fig. 102.

Fig.		£	s.	d.
103.	Simple Alkalimeter Tube	0	6	0
104.	Binks' Alkalimeter	0	6	0
105.	Schuster's Alkalimeter	0	2	0
106.	Cylindrical Graduated Glasses, on feet, containing 10,000 grains	0	12	0
	Specific Gravity Bottles, containing 250, 500, or 1000 grains	0	5	0
	Ditto in Tin Case, with Counterpoise	0	7	6
	Knight's Specific Gravity Apparatus, in mahogany box, complete	0	15	0
107.	Parnel's Apparatus for testing Carbonates See Normandy's Guide to Alkalimetrical Chest.	0	2	6
108.	Fresenius and Wills' Apparatus for analysing Carbonates	0	2	6

CHEMICAL BALANCES.

109.	Chemical Balance, with best box-end Steel Beam, on Brass Pillar, for taking specific gravities. Set of Decimal Weights, from $\frac{1}{2}$-grain to 500 grains. The whole fitted in a neat mahogany box	2	12	6
	Chemical Balance, with Sight-hole Beam, mounted on Brass Pillar, with Tripod Foot, and fine adjustments for raising the beam. Decimal Weights from $\frac{1}{10}$ gr. to 1000 grains. Extra Scale. Glass Bulb and Bucket, for taking the specific gravity of solids and fluids. The whole fitted in a neat mahogany box	5	15	6
	Analytical Balance, with Sight-hole Beam, on Brass Pillar, with German Silver Pans and Weights from 5 grains to 100, and Platina Weights from 5 grains to $\frac{1}{32}$ gr. The whole fitted in a neat mahogany box	4	4	0
	Analytical or Assay Balance, with best Steel Sight-hole Beam, German Silver Pans, and Weights of German Silver and Platina to the $\frac{1}{100}$ gr. The whole in glass lantern, with sliding front	7	7	0
110.	Analytical Balance, German pattern, with 16-in. beam, to carry 1000 grains in each pan, and turn with the $\frac{1}{200}$ grain. The beam is divided and furnished with a moveable arm inserted in the case above the beam for moving the "rider." Extra Pan for weighing potash apparatus and taking specific gravities. The whole in glass lantern with adjusting screws	16	16	0
	Balance with 16-in. beam, to carry 1 lb. in each pan, and turn with the $\frac{1}{20}$ of a grain. In glass lantern	9	9	0
	Chemical Scales for the rougher purposes of the laboratory 1*l.* 10*s.* to	5	5	0
	Strong Beams, either with hook or box ends, Brass Pans with Brass Pillar, mounted on mahogany box, with drawer for weights 18*s.* 6*d.* to	2	2	0

WEIGHTS.

	Set of Flat Brass Weights, from $\frac{1}{4}$ oz. to 1 lb.			
	Ditto „ 2 lbs.			
	Ditto „ 4 lbs.			
	Ditto „ 7 lbs.			
	Cup-form Weights.			
	Troy Weights, from $\frac{1}{4}$ oz. to 1 lb., the set	0	5	0
	Avoirdupois ditto „ „	0	5	0

Fig.		£	s.	d.
	Decimal Grain Weights, from $\frac{1}{100}$ gr. to 1000 grains, with Forceps. In mahogany box, complete			
	Decimal Grain Weights, from $\frac{1}{1000}$ gr. to 1000 grains, the small weights being of platina, with Forceps. In mahogany box, complete	0	15	0
	Assay Weights, for gold and silver			
	Set of Foreign Weights made to order, from 50 grammes to 1 millegramme, with Forceps, complete. In mahogany box	1	15	0

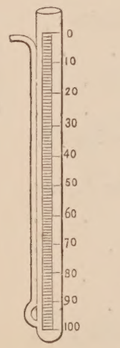


Fig. 103.

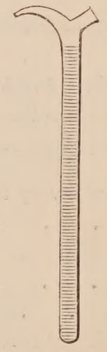


Fig. 104.

Fig. 105.

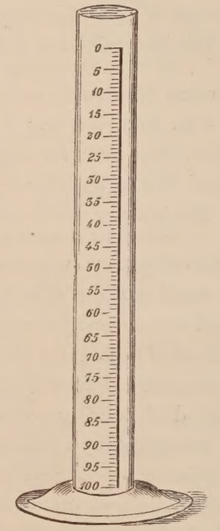


Fig. 106.

Fig. 107.

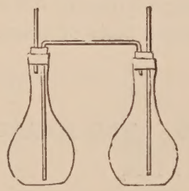


Fig. 108.

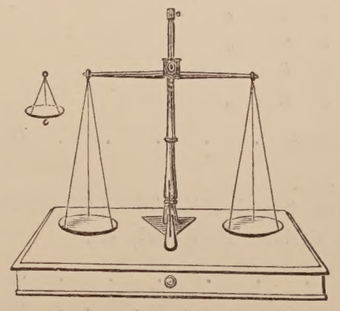


Fig. 109.

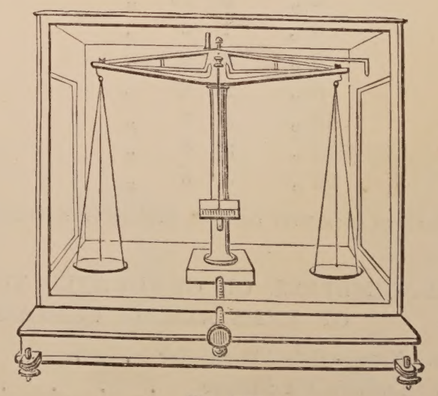


Fig. 110.

Fig.

EVAPORATING DISHES, CRUCIBLES, &c., OF BERLIN PORCELAIN.

111. Evaporating Dishes, the depth about one-third the diameter :—

No.	Diameter.	Price. s.	d.	No.	Diameter.	£	s.	d.
00	$2\frac{3}{4}$ in.	0	6	6	6 in.	0	2	0
0	$3\frac{1}{4}$ „	0	7	7	$7\frac{1}{4}$ „	0	2	6
1	$3\frac{1}{2}$ „	0	9	8	$8\frac{1}{2}$ „	0	3	6
2	$3\frac{3}{4}$ „	1	0	9	10 „	0	5	0
3	4 „	1	2	10	12 „	0	8	0
4	$4\frac{1}{2}$ „	1	4	11	14 „	0	9	0
5	$4\frac{3}{4}$ „	1	8	12	$15\frac{1}{2}$ „	1	4	0

112. Evaporating Dishes, with flat bottoms and lip ; flatter form :—

No.	Diameter.	Price. s.	d.	No.	Diameter.	£	s.	d.
1	$2\frac{3}{4}$ in.	0	6	5	$4\frac{1}{2}$ in.	0	1	3
2	3 „	0	9	6	5 „	0	1	6
3	$3\frac{1}{2}$ „	0	10	7	6 „	0	1	10
4	4 „	1	0					

113. Evaporating Dishes, hemispherical form :—

No.	Diameter.	Price. s.	d.	No.	Diameter.	£	s.	d.
1	$5\frac{1}{2}$ in.	2	6	4	$8\frac{1}{2}$ in.	0	5	0
2	$6\frac{1}{2}$ „	3	0	5	$9\frac{1}{2}$ „	0	6	0
3	$7\frac{1}{2}$ „	4	0					

Evaporating Dishes, thin, for Analytical Experiments, hemispherical form :—

No.	Diameter.	Price. s.	d.	No.	Diameter.	£	s.	d.
000	1 in.	0	3	3	2 in.	0	0	10
1	$1\frac{1}{2}$ „	0	6	4	$2\frac{1}{4}$ „	0	1	0
2	$1\frac{3}{4}$ „	0	8	5	$2\frac{1}{2}$ „	0	1	3

114. Basins, with Spout and Handle :—

No.	Diameter.	Price. s.	d.	No.	Diameter.	£	s.	d.
1	$1\frac{1}{2}$ in.	0	10	3	$2\frac{3}{4}$ in.	0	1	2
2	2 „	1	0	4	$3\frac{1}{2}$ „	0	1	4

114 A. Capsules, or Basins, with Lip and Ring Handles, of Berlin Porcelain :

	£	s.	d.
No. 1	0	0	7
„ 2	0	0	8
„ 3	0	1	0
„ 4	0	1	8
„ 5	0	3	4

115 A. Capsules, or Basins, with Lip and two Arms, of Berlin Porcelain 0 4 6

116 A. Capsules, or Basins, with Lip of Berlin Porcelain, with Wooden Handles . . 0 1 6

115. Digesting Vessels, egg-shaped :—
No. 1.—Contents, $1\frac{1}{2}$ oz., price 9*d.* No. 2.—Contents, 3 oz. 0 0 10

116. Drainers, saucer-shaped, with Handles :—
5 in. diameter, and $1\frac{1}{2}$ in. deep . . . . . each 0 1 6

Fig.

117. Drainers, basin-shaped, for draining Crystals :— £ s. d.
$5\frac{1}{2}$ in. diameter, and $2\frac{1}{2}$ in. deep . . . . . each 0 2 0

118. Drainers, funnel-shaped :—
No. 1 Diameter $4\frac{1}{2}$ in. Depth $4\frac{1}{2}$ in. 0 1 9
2 „ 5 „ „ $5\frac{1}{2}$ „ 0 2 3
3 „ 7 „ „ $6\frac{1}{2}$ „ 0 3 9

119. Filter Dryers, all in one piece, and similar to Pepy's . . . . . each 0 2 6

Crucibles and Covers, Cone-shaped :

	£	s.	d.
No. 000. Contents, 1 drachm	0	0	3
1 „ 2 „	0	0	5
2 „ 3 „	0	0	6
3 „ $\frac{1}{2}$ oz.	0	0	8
4 „ 1 „	0	0	10
5 „ $1\frac{1}{2}$ „	0	1	0

Fig. 111.

Fig. 112.

Fig. 113.

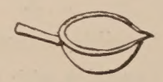


Fig. 114.

Fig. 114 A.

Fig. 115 A.

Fig. 116 A.

Fig. 115.

Fig. 116.

Fig. 117.

Fig. 118.

Fig. 119.

Fig.		£	s.	d.
121.	Crucibles and Covers, very thin, and deeper (Meissen) :			
	No. 1. Contents, 22 drops	0	0	5
	„ 2. „ ½ drachm	0	0	5
	„ 3. „ 1 „	0	0	6
	„ 4. „ 2 „	0	0	7
	„ 5. „ ⅓ oz.	0	0	7
	„ 6. „ ½ „	0	0	8
	„ 7. „ 1¼ „	0	0	8
	„ 8. „ 2 „	0	0	10
	„ 9. „ 3 „	0	1	0
	„ 10. „ 5 „	0	1	4
	„ 11. „ 8 „	0	1	9
	Crucibles and Covers, Cylinder-shaped (Berlin) :			
	No. 1. Contents, ½ oz.	0	0	6
	„ 2. „ 1 „	0	0	7
123.	Crucibles and Covers, for Fusing Nitrate of Silver :			
	No. 1. Contents, 1 oz.	0	0	7
	„ 2. „ 2¾ „	0	0	8
124.	Crucible, Conical-shaped, containing 16 oz.	0	1	3
125.	Crucibles, with perforated Covers, or Berlin Assayers :			
	No. 1. Contents, 3 oz.	0	1	3
	„ 2. „ 6 „	0	1	6
126.	Digesting Vessels, with Ground Covers and Handle :			
	No. 1. Contents, 8 oz.	0	3	0
	„ 2. „ 16 „	0	4	0
	„ 3. „ 21 „	0	6	0
127.	Funnels of Glazed Porcelain for filling vessels	0	1	9
128.	Mercurial Trough, to hold 4 lbs.	0	2	6
129.	Mercurial Trough to hold 10 lbs.	0	8	6
130.	Mercurial Bottle to hold the Quicksilver	0	2	6
131.	Retorts, plain :			
	Contents, 3 oz.	0	2	6
	„ 6 „	0	3	6
	„ 12 „	0	6	0
132.	Retorts, Tubulated, with Stoppers :			
	Contents, 3 oz.	0	3	6
	„ 6 „	0	5	0
	„ 12 „	0	8	0
133.	Spoons, perforated for Draining	0	2	6
134.	Spoons, plain, with Ring Handle	0	2	6
135.	Spoons, with Long Handles	0	2	0

Fig.		£	s.	d.
136.	Spoons, with Upright Handles	0	2	0
137.	Spatulas	0	0	5
138.	Ditto	0	0	6
139.	Ditto	0	0	7

Fig. 121.

Fig. 123.

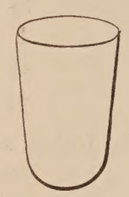


Fig. 124.

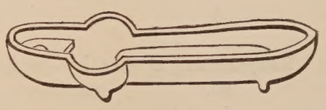
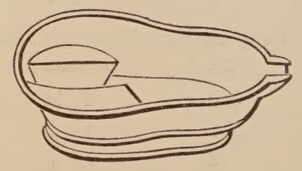


Fig. 128.

Fig. 125.

Fig. 126.

Fig. 127.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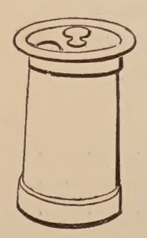
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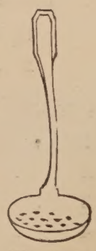


Fig. 133.

Fig. 134.

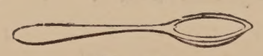


Fig. 135.

Fig. 136.

Fig.

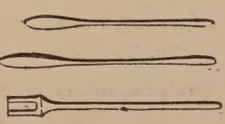


Fig.		£	s.	d.
140.	Sulphuric Acid Dish, for Air-Pump	0	4	6
	Tubes of Berlin ware, from 12 inches to 2 feet in length, and from ½ inch to 2½ inch diameter, 2s. to	1	16	0
141.	Trays of Berlin ware, for use with Tubes, three sizes	0	0	6
142.	Supports for Funnels, with three arms	0	0	6
143.	Ditto, with two arms	0	0	6
144.	Water-Baths of Porcelain, in two separate pieces :			
	No. 000	0	2	6
	„ 00	0	3	6
	„ 1	0	5	0
145.	Alembics, of Berlin ware, in two separate pieces	0	5	0
	Mortars and Pestles for Mixing, of Berlin ware :			
	No. 1. Diameter 2 inches	0	0	9
	„ 2 „ 3½ „	0	2	6
	„ 3 „ 4½ „	0	3	6
	„ 4 „ 5 „	0	4	6
	Mortars and Pestles, for Apothecaries' use :			
	No. 1. Diameter 5½ inches	0	3	6
	„ 2 „ 7 „	0	5	6
	„ 3 „ 8½ „	0	7	6
	Mortars and Pestles, Meissen ware :			
	Diameter. Height.			
	3¼ inches 2⅛ inches	0	3	4
	4½ „ 2¾ „	0	4	6
	5 „ 3¼ „	0	6	0
146.	Mortars and Pestles, of Agate, vary in price according to size, from 5s. 6d. to	5	5	0
147.	Mortars and Pestles, Wedgewood ware :			

No.	Diameter.	Contents.	£	s.	d.
0000	2¾ inch	2 oz.	0	0	9
000	3 „	3 „	0	1	0
00	3½ „	4 „	0	1	2
0	3¾ „	5 „	0	1	4
1	4¼ „	8 „	0	1	8
2	5 „	12 „	0	2	3
3	5½ „	16 „	0	2	9
4	6 „	22 „	0	3	9
5	6½ „	26 „	0	4	3
6	7 „	36 „	0	5	0
7	8 „	2½ pints	0	6	3
8	9¼ „	3 „	0	8	0
9	10½ „	5 „	0	10	0
10	12 „	6 „	0	11	6
11	13 „	5 quarts	0	12	0
12	14 „	6 „	0	14	0

Fig.		£	s.	d.
148.	Cast-iron Mortars and Pestles, Bell-shaped :			

No.	Diameter.	Contents.	£	s.	d.
0	3½ inches	6 oz.	0	1	4
1	4 „	8 „	0	1	6
2	4½ „	¾ pint	0	2	0
3	5 „	1 „	0	2	3
4	5½ „	1½ „	0	2	9
5	6 „	2 „	0	3	6
6	6½ „	3 „	0	4	3
7	7 „	4 „	0	5	0
8	8 „	5 „	0	6	3
9	9 „	3 quarts	0	8	0
11	11 „	5 „	0	12	0

Fig.		£	s.	d.
149.	Cast-iron Mortars and Pestles, Wedgewood-shaped :			

No.	Diameter.	Contents.	£	s.	d.
1	4 inches	½ pint	0	2	6
2	5 „	1 „	0	4	0
3	6 „	1 quart	0	5	6
4	7¼ „	3 pints	0	6	0

150.	Knight's Improved Cast-iron Pestle and Mortar, with Cover, for pounding hard substances, minerals, &c.	1	11	6
	Steel Mortar and Pestle, for the reducing to powder valuable gems, and other hard substances, for blowpipe or chemical examination	0	15	0

Fig. 140.

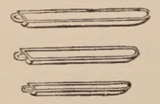


Fig. 141.

Fig. 142.

Fig. 143.

Fig. 144.

Fig. 145.

Fig. 146.

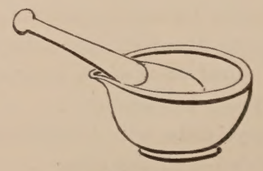


Fig. 147.

Fig. 148.

Fig. 149.

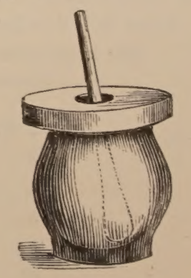


Fig. 150.

GAS APPARATUS.

Fig.		£	s.	d.
151.	Pneumatic Trough, for collecting Gases over water, made in Japanned Tin :			
	10 in. by 7 in., 7 in. deep	0	5	0
	13 in. by 9 in., 9 in. deep	0	12	0
	16 in. by 12 in., 12 in. deep	0	18	0
152.	Narrow and Deeper form, allowing the jars being filled without removal from the trough . . . . . 12*s.* to	0	21	0
153.	Knight's Improved Pneumatic Trough, by which a large surface of shelf-room is obtained with comparatively little water	1	5	0
	Pneumatic Troughs, for collecting Gases over mercury :			
154.	Ollerenshaw's form of Iron Mercurial Trough, applicable with only 7 lbs. mercury	0	18	0
	The same, on Legs, with Well	1	17	0
	Cast-iron Mercurial Troughs . . . . . from 10*s.* to	1	11	6
	Newman's Improved Iron Mercurial Trough, with Gasometer attached, Glass Bell, Air-Jar, &c., complete	12	12	0

GAS-HOLDERS.

155.	Plain Gas-Holders, with Funnel and Stop-Cock . . . . . 12*s.* to	1	1	0
156.	Pepys' Improved Gas-Holders . . . . . 21*s.* to	5	5	0
	This is the most convenient form of Gas-Holder, and is made of tin, japanned.			
	Brass Stop-Cocks, for Gas-Jars, Gasometers, &c. (161*a*)	0	3	6
	A great variety of Brass Connecting Pieces, Union Screws, Brass Caps, &c. &c. . . . . from 1*s.* to	0	3	6
	Flexible Metallic Tube, for conducting Gas			
	Vulcanized Indian-Rubber Tubing, see page 17			
	Deflagrating Spoons, with Shifting Box, to burn substances in Gases	0	2	6
	Plain do. do.	0	0	6
	Forceps for introducing substances into gas through water or mercury	0	5	0
157.	Shallow Japanned Trays, for transferring jars of Gas, from 3 in. to $8\frac{1}{2}$ in. diameter	0	3	0

EUDIOMETERS, OR TUBES FOR THE ANALYSIS AND EXAMINATION OF GASEOUS BODIES

158.	Volta's Detonating Eudiometer . . . . . 10*s.* to	0	15	0
	Spring Stand, for supporting this instrument, and preventing the spilling and consequent waste of the mercury when in use	0	12	0
158 A.	Hope's Eudiometer	0	8	0
159.	Pepys' ditto, with Elastic Bottle	0	8	6
160.	Ure's Detonating ditto	0	9	6
160 A.	Davy's ditto	0	8	6

161. Glass Bell Air-Jars, for collecting Gases, with Welt at bottom :

(The height given is to the bottom of the necks.)

Diameter.		Depth.	Plain. s. d.	Stoppered. s. d.	Capped. s. d.
3 in.	by	$4\frac{1}{2}$ in.	1 6	2 3	4 0
3	„	5	2 0	2 9	5 0
4	„	7	3 0	3 9	5 6
5	„	8	4 0	5 0	6 6
$5\frac{1}{2}$	„	9	5 0	6 0	8 0
$6\frac{1}{2}$	„	$10\frac{1}{2}$	6 0	7 6	9 6

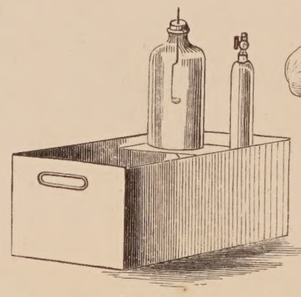


Fig. 151.

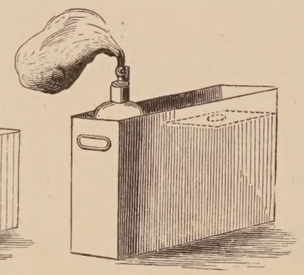


Fig. 152.

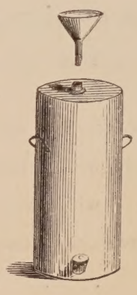


Fig. 155.

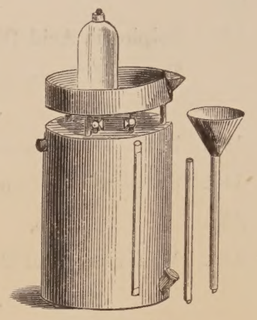


Fig. 156.

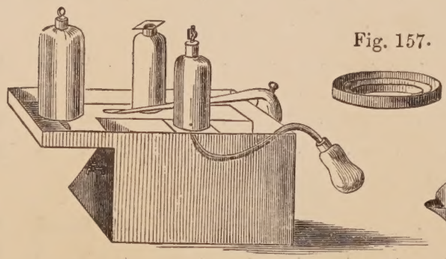


Fig. 153.

Fig. 157.

Fig. 161.

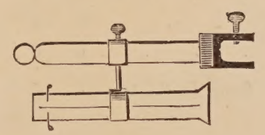


Fig. 158.

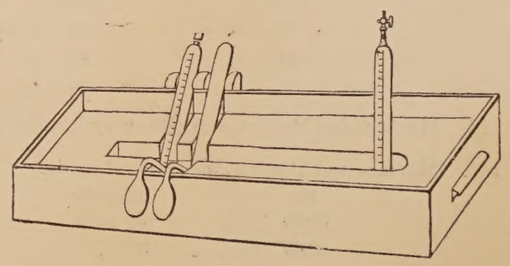


Fig. 154.

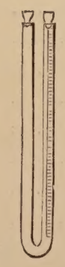


Fig. 160 A.

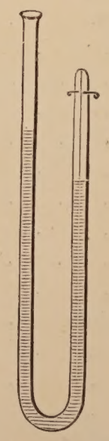


Fig. 160.

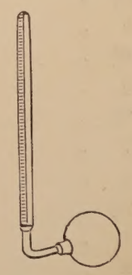


Fig. 159.

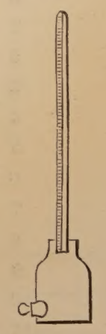


Fig. 158 A.

Fig.		£	s.	d.
161.	Glass Bell Air-Jars—*continued:*			
	Graduated and Stoppered:			
	50 cubic inches	0	5	6
	100 „	0	8	0
	150 „	0	10	6
	240 „	0	12	6
	Graduated and Capped, for Stop-Cock:			
	50 Cubic Inches	0	9	0
	100 „	0	12	0
	150 „	0	14	6
	240 „	0	16	6
	Tubes, containing a cubic inch divided into tenths and hundreths, each	0	5	0
	Cylindrical Gas-Jars, singly or in sets			
	Two-necked Bottle, with Stopper and bent Tube, for generating certain Gases, pint size	0	2	6
	Glass Flasks, mounted with Tubes, for disengagement of Gases . from 1*s.* to	0	2	6
162.	Cavendish's Apparatus for detonating the mixed Gases in larger quantities than can be effected with an Eudiometer, and without the aid of a mercurial trough	2	2	0
	Philips's Bottle, for detonating the mixed Gases by the aid of Sponge Platina	0	7	6
	Thin Glass Flasks, mounted with Brass Cap and Stop-Cock, for taking the specific gravity of Gases	0	7	6

Woulffe's Bottles.

These useful vessels take their name from their inventor, and are used for passing gaseous bodies through liquids, either for the purpose of washing the former or impregnating the latter. They are made with either two or three necks, so as to allow cocks to be fitted to them.

Capacity.	2 Necks. s.	d.	3 Necks. s.	d.	Capacity.	2 Necks. s.	d.	3 Necks. s.	d.
10 oz.	1	0	1	6	6 pints	5	0	5	6
1 pint	1	6	1	9	8 „	7	6	8	0
2 „	2	6	3	0	10 „	8	6	9	0
4 „	4	0	4	6					

163.	Set of Three 3-necked Woulffe's Bottles in a Tray, with appropriate Tubes, forming a very useful apparatus, 32 oz. size	1	1	0
	Pepys' Apparatus for transferring small quantities of Gas from one vessel to another	0	7	6

Flasks for Generating Gases, with Bent Tube:

Capacity.	Plain. s.	d.	Stoppered. s.	d.
8 oz.	2	8	4	6
1 pint	3	4	5	0
2 „	5	0	6	6

Gas Bags, Wedge-shaped, of Brown Twill, and lined with Indian Rubber:

Length.	Width.	In Wedge.		£	s.	d.
20 in.	12 in.	12 in.	each	1	4	6
24	20	14	„	2	3	6
26	26	14	„	2	14	6
30	24	18	„	3	4	6
36	30	20	„	4	10	6
40	32	20	„	5	4	6

Other sizes may be had. Fig. 27.

APPARATUS USED IN ORGANIC ANALYSIS, &c.

Fig.		£	s.	d.
165*a*.	Combustion Furnace, after the Geissen pattern, made of stout Sheet Iron, as Fig. A,D.	0	11	6
	Combustion Furnace, same pattern, made of slight Sheet Iron	0	5	6
166.	Combustion Tubes, for Furnace . . . . . per dozen, 12*s.*, or each	0	1	3
	Thin Copper Ribbon, for wrapping round the Combustion Tube, to prevent its being melted			
167.	Liebig's Potash Bulb, made of light hard German Glass, in Case	0	3	0
168.	Chloride Calcium Tubes, for absorbing the moisture produced in analysis . each	0	0	9

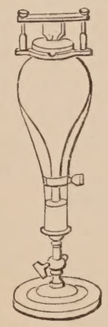


Fig. 162.

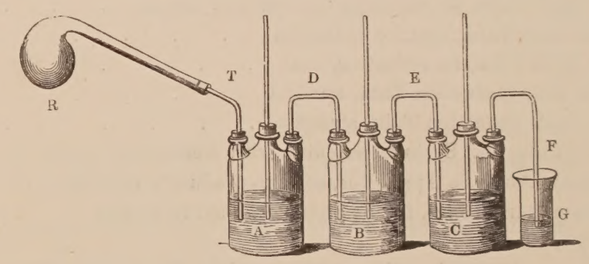


Fig. 163.

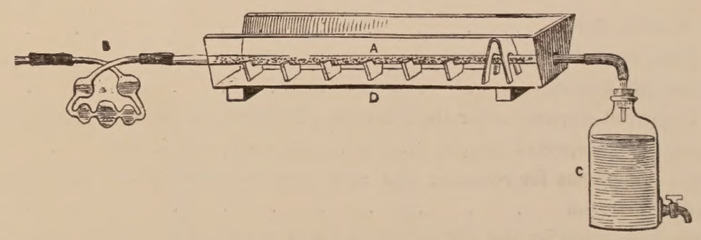


Fig. 165 *a*.

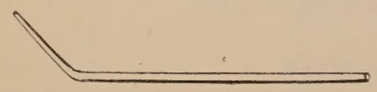


Fig. 166.

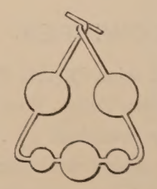


Fig. 167.

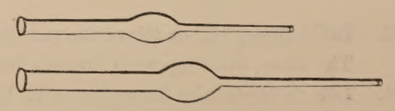


Fig. 168.

Fig.		£	s.	d.
169.	Bent Tube, for drying Organic Bodies	0	1	9
170.	Three-limbed Tube, for adjusting to Exhausting Apparatus or Air-Pump	0	1	9
171.	Pipette, bent, for passing Solutions in a Gas over Mercury	0	1	0
172.	Suction Tube, used to ascertain if all the connections are air-tight, by adapting it to Potash Bulb	0	1	0
173.	Letter Z Tube, for adjusting to Exhausting Apparatus, &c.	0	1	0
174.	Dr. Ure's Apparatus, for the determination of Nitrogen	0	4	0
175.	Will's and Varrentrap's Apparatus, for determining the quantity of Nitrogen	0	2	0
176.	Mitscherlick's Potash Apparatus, made of light hard German Glass	0	3	6
177.	Connecting Tube, bent	0	1	9
178.	Graduated Glass Cylinder, for the collection of Gases, graduated into 250 cubic centimeters	0	10	6
	Brunner's Bottle, with Tube and Funnel, for drying substances, and for ascertaining a known quantity of passing air, fitted with stop-cock near the bottom	0	10	6
	Large Bulb Tube, for weighing the Oxide of Copper	0	0	8
	Double Bulb Tube, bent for reduction	0	1	3
179.	Single Bulb Tube, for reduction, bent	0	1	0
180.	Double Bulb Reduction Tube, straight	0	1	3
181.	Single Bulb Reduction Tube, straight	0	1	0
	Small Exhausting Syringe, supplied with connecting pieces, for adapting to the Organic Analysis Apparatus, so as to produce a vacuum	1	8	0
	Geissen pattern Tongs, for supplying charcoal to furnace	0	3	6

TUBES AND APPARATUS FOR TESTING ARSENIC.

182A.	Tube Berzelius, for detecting Arsenic by reduction and sublimation, made of German Glass . . . . . 4*d.* and	0	0	6
	Small Long Funnel, for the introduction of matters, for Testing, into the Tubes, 4*d.* and	0	0	6
182D.	Clarke's Arsenic Tube	0	0	3
182C.	Liebig's Tube, for detecting Arsenic	0	0	3
182B.	Rose's Tube, for Arsenic	0	0	3
	Marsh's Improved Apparatus for the detection of Arsenic, by producing arseniated Hydrogen from suspected liquids, fitted with stop-cock, and on foot	0	12	0
	Christison's Apparatus for reducing the sulphurets of some of the metals by a stream of Hydrogen	0	7	6
	Christison's Apparatus for the distillation of fluids suspected to contain acids	0	2	6

BLOWPIPES.

183.	Table Blowpipe, or Glass Blower Table, with Double Bellows and Lamp, complete	4	4	0
	The same, fitted up with Drawer for Glass Tubes, Foot, and small Table Vice	5	5	0
184.	Tilley's Hydraulic Blowpipe, with Lamp, complete	2	5	0
185.	Johnson Toft's Improved Hydraulic Blowpipe, with Lamp, complete	3	3	0
	Hook's Self-acting Spirit Blowpipe, with Lamp, complete	1	11	6
	Maugham's Improved Modification of Daniel's Jet, by which the Oxygen and Hydrogen Gases may be burned in any quantity with perfect safety	0	17	6

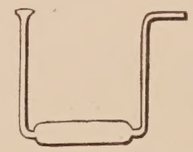
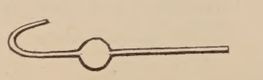


Fig. 169.

Fig. 170.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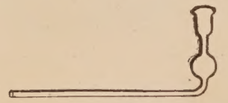
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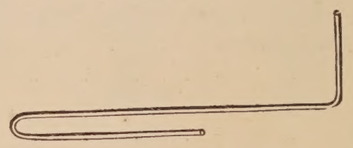
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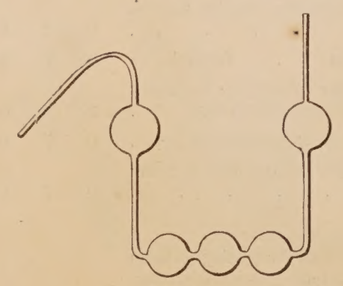
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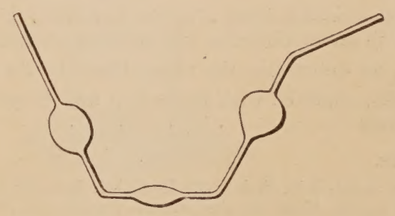
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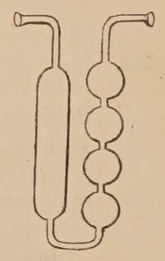
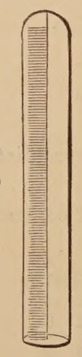


Fig. 176.

Fig. 177.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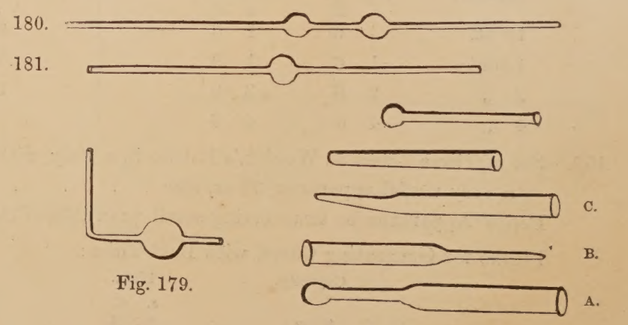


Fig. 179.

Fig. 182 B. C. D.

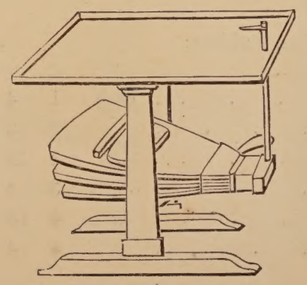


Fig. 183.

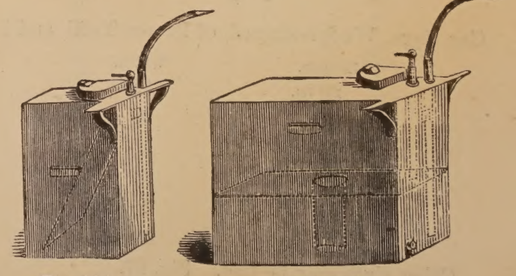


Fig. 184.

Fig. 185.

Fig.		£	s.	d.
186.	Hemmings's Safety Jet, for burning the mixed Gases	0	10	0
	Compression Blowpipe, consisting of a Mahogany Frame, with Bladder for the Gases, Lead Weights, and fitted with a Hemmings's Jet	2	12	6

MOUTH BLOWPIPES.

187.	Simple Brass Blowpipes, of the ordinary form . . . . . 8*d.* to	0	1	6
188.	Ball Blowpipe, intended to condense the moisture of the breath	0	2	6
	The same, with Ivory Mouth-piece	0	3	0
189.	Superior finished ditto, with Ivory Mouth-piece, and three different sized Jets	0	5	6
190.	Pepys' Improved Blowpipe, with flat-shaped Condenser, Jointed Limb, and three different sized Jets	0	8	6
	Berzelius, or Gahn's Blowpipe, either with straight or trumpet-shaped Mouth-piece	0	8	6
	Wollaston's Pocket Blowpipe, in three different pieces, and packs up to a pocket-pencil size	0	7	6
191.	Dr. Black's Blowpipe, in Japanned Tin	0	1	0
191 a.	Glass's Blowpipe, with Lamp, for blowing glass	0	7	6
	Platina Jets, suited for most of the above Blowpipes . . . . . each	0	2	6

THERMOMETERS.

192.	Chemical Thermometers, with boxwood Scale, the lower part of which being jointed, allows of the bulb being immersed into a liquid. Divided to 300 Fah. .	0	6	6
	„ „ 450 „ .	0	8	6
	„ „ 600 „ .	0	12	0
193.	Chemical Thermometers, graduated on the Glass Tube, useful for placing through the stopper hole of a Retort, so as to ascertain the Temperature during operations. In wood case . . . . . 7*s.* to	0	12	0
	Chemical Thermometer with Paper Scale, enclosed in a Glass Tube . . 6*s.* to	0	14	0
	Ditto, with White Glass Scale . . . . . 10*s.* to	1	0	0
	Spirit Thermometer for low Temperatures . . . . . 6*s.* 6*d.* to	0	14	0

Vulcanized India-Rubber Tubing, very useful for making Connections :—

No.	Diameter.	Price per foot. s.	d.	No.	Diameter.	Price per foot. s.	d.
1	$\frac{1}{24}$ inch. ...	0	1	9	$\frac{3}{8}$ inch ...	0	9
2	$\frac{1}{16}$ „ ...	0	1	10	$\frac{3}{8}$ „ stouter make	0	10
3	$\frac{1}{12}$ „ ...	0	$2\frac{1}{2}$	11	$\frac{1}{2}$ „ ...	1	0
4	$\frac{1}{8}$ „ ...	0	$3\frac{1}{2}$	12	$\frac{5}{8}$ „ ...	1	1
5	$\frac{1}{7}$ „ ...	0	5	13	$\frac{3}{4}$ „ ...	1	2
6	$\frac{1}{6}$ „ ...	0	6	14	$\frac{7}{8}$ „ ...	1	3
7	$\frac{1}{3}$ „ ...	0	7	15	$\frac{7}{8}$ „ stouter make	1	5
8	$\frac{1}{4}$ „ ...	0	8				

Larger Diameter Tubing may be had.

Fig.

Hard German Glass Tubing :—
Diameter $\frac{1}{8}$ inch, $\frac{1}{6}$, $\frac{1}{5}$, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{3}$, very thick, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$ inch, from 2*s.* 6*d.* to 3*s.* per lb.
English or Flint Glass Tubing, as the above in diameter, from 1*s.* 6*d.* to 2*s.* per lb.
Glass Rods, for Stirrers, &c., 1*s.* 6*d.* per lb.

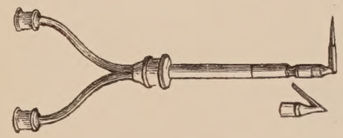
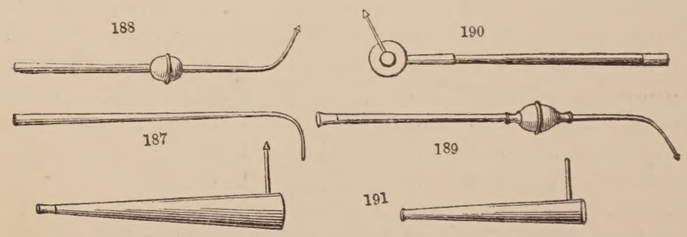


Fig. 185 *a*.

Fig. 186.

Fig. 191 A.



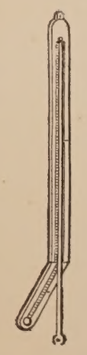


Fig. 192.

Fig. 193.

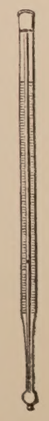


Fig. 194.

STILLS AND WORM TUBS.

Fig.		£	s.	d.
195.	Stills, made in Tinned Iron, with Refrigerator, adapted to place on a common fire; useful for the distillation of water, &c. 1 gallon size, 1*l.* 1*s.*; 2 gallon . .	1	7	6
196.	Portable Stills, constructed in Copper, tinned inside, with Pewter Head and Neck, Iron Plate, Furnace, Pewter Worm in Wooden Tub, complete :			
	1 gallon	5	5	0
	2 „	6	6	0
	4 „	7	17	6
	6 „	10	10	0
	Larger sizes made to order.			
	Stills, for setting in brick-work			

197. Very accurate Stoppered Bottles, for chemical tests :

Size.	Price—Wide Mouth.	Price—Narrow Mouth.	With Glass Cap.
½ oz. and smaller	0*s.* 5*d.*	0*s.* 4*d.*	
1	0 6	0 5	1*s.* 6*d.*
2	0 8	0 7	2 0
3	0 8	0 8	3 0
4	0 9	0 8	3 0
6	0 10	0 9	4 0
8	1 0	0 10	4 0
12	1 2	1 0	
16	1 6	1 4	
20	1 6	1 4	
32	2 6	2 0	

Bottles with Enamelled or Engraved Labels made to order, 2*s.* each extra on the above prices.

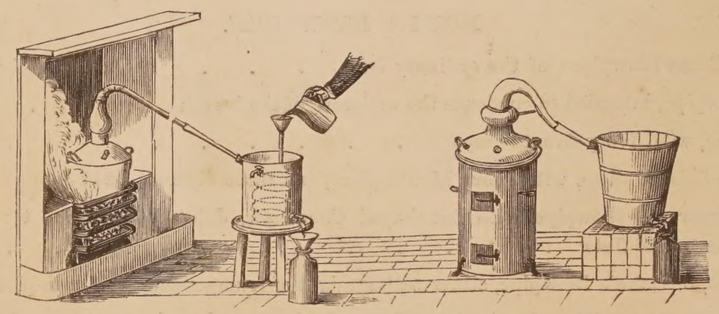


Fig. 195.

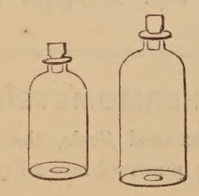


Fig. 197.

Fig. 196.

LIST OF CHEMICAL TESTS AND RE-AGENTS.

The following Prices are subject to variation, and are for the quantity stated; large orders will be charged at a lower price.

	£	s. lb.	d.	s. oz.	d.
Acid,					
Acetic, "strong"	0	1	0	0	1
Aqua Regia	0	2	0	0	3
Arsenic	0	5	0	0	6
Arsenious	0	1	0	0	2
Benzoic	1	2	6	1	6
Boracic	0	6	0	0	6
Butyric	1	12	6	2	6
Chromic	0	18	0	2	0
Carbazotic		—		3	6
Fluosilicic	0	4	0	0	4
Formic	0	5	0	0	6
Hydrochloric	0	0	3		—
Hydrochloric, pure	0	1	0	0	2
Hydrocyanic	0	2	6	0	6
Hydrofluoric	0	5	0	0	6
Lactic	1	3	0	2	0
Lithic	1	2	6	2	0
Iodic		—		5	0
Molybdic		—		5	0
Nitric	0	1	0		—
Nitric, pure	0	1	6	0	2
Nitric, "fuming," sp. grav. 1·500	0	2	6	0	3
Nitrous	0	1	6	0	2
Oxalic	0	3	0	0	4
Phosphoric, "glacial"	0	16	0	1	6
Diluted, P.L.	0	3	6	0	4
Succinic	2	8	0	5	0
Sulphuric	0	0	3		—
Sulphuric, pure	0	1	6	0	2
„ Nordhausen	0	2	6	0	3
Sulphurous	0	1	0	0	2
Tartaric	0	2	6	0	3
Tunsgtic		—		4	0
Tannic		—		2	0
Uric	1	4	0	2	0
Valerianic	2	4	0	3	6
Vanadic, per grain, 1*s.* 6*d.*					
Alcohol	0	4	0	0	3
Absolute	0	6	0	0	6
Mythilated Spirit, per pint, 1*s.* 6*d.*					
Alum, Potash Com.	0	0	3		—
Ammonia, Pure	0	5	0	0	6
Alumina, Pure	0	16	0	1	6
Sulphate, free from Iron	0	0	8		—
Aluminium		—		12	0
Ammonia, Solution, sp. grav. 0·940	0	1	0		—
„ sp. grav. 0·880	0	1	6	0	2
Acetate	0	6	0	0	6
Arseniate	0	6	0	0	6
Benzoate		—		3	0
Borate	0	4	0	0	6
Carbonate	0	1	0		—
„ pure	0	3	0	0	3
Hydrochlorate	0	2	6	0	3
„ pure	0	7	6	0	6
Nitrate, pure	0	4	6	0	6
Oxalate, pure	0	6	0	0	6
Ammonia, Phosphate and Soda	0	14	0	1	0
Succinate		—		4	0
Urate	0	14	0	1	0
Ammonium, Chloride	0	6	0	0	6
Iodide		—		3	6
Sulphide	0	3	6	0	4
Antimony, Regulus (varies)	0	0	10		—
Oxide	0	3	6		—
Tartrate and Potass	0	5	0	0	6
Terchloride, Crystals		—		3	6
Arsenic, Metallic	0	2	6	0	3
Oxide, "White"	0	0	6	0	2
Asbestos	5*s.* to	0	12	0	6
Barium, Fluoride, pure	0	6	0	0	6
Baryta, pure	0	14	0	1	0
Acetate, Crystals	0	14	0	1	0
Carbonate	0	6	0	0	6
Native	0	0	4		—
Chlorate	0	3	6	0	4
Nitrate, pure	0	3	6	0	4
Phosphate					
Sulphate, native	0	0	4		—
Bismuth (varies)	0	3	0	0	4
Nitrate	0	8	0	0	8
Trisnitrate	0	8	0	0	8
Oxide	0	6	0	0	6
Bone Ash, for Cupels	0	0	8		—
Borax	0	1	6	0	2
Dried	0	3	6	0	4
Glass of	0	4	0		—
Bromine (varies)		—		2	6
Bromine, Chloride		—		3	0
Cadmium (varies)	1	0	0	2	0
Bromide		—		3	6
Chloride		—		4	0
Iodide		—		3	6
Nitrate		—		4	0
Oxide		—		3	0
Sulphate		—		4	0
Calcium, Chloride, Crystals	0	1	0	0	2
„ Fused	0	2	6	0	3
Hypochlorite	0	1	0		—
Phosphate	0	10	0	1	0
Sulphide	0	7	6	0	6
Phosphide	0	12	0	1	0
Carbon, Bisulphuret (varies)	0	2	0	0	3
Charcoal, Vegetable	0	1	0		—
Animal, pure	0	6	0	0	6
Alder	0	1	0		—
Boxwood		—		0	4
Chlorine Solution	0	1	0	0	2
Chromium,					
Carbonate	0	12	0	1	0
Oxide	0	12	0	1	0
Sulphate and Potass	0	8	0	0	6
Clay, Stourbridge	0	0	3		—
China	0	0	6		—
Cobalt, Regulus		—		5	0
Acetate, Crystals		—		4	6
Chloride, Crystals		—		4	0
Nitrate, Crystals		—		4	0
Oxide, per oz. 1*s.* 6*d.* to 5*s.*					
Copper (pure alloy)	0	2	6	0	3
Acetate	0	2	6	0	3
Chloride		—		1	0
Nitrate	0	4	0	0	6
Oxide, pure, for Organic Analysis	0	4	0	0	4
Proto Oxide		—		2	0
Sulphate	0	4	0	0	4
Dextrine, or British Gum	0	1	0		—
Distilled Water, per gallon, 6*d.*					
Donovan's Solution		—		0	6
Ether, Sulphuric, Rectified	0	6	6	0	6
Pyroligneous, for burning	0	1	6	0	2

	£	s.	d.	s.	d.
		lb.		oz.	
Fluor Spar	0	0	4	—	
Flux, Black	0	5	0	0	6
White	0	5	0	0	6
Gold Leaf, per book, 1*s.* 9*d.*					
Terchloride, Crystals (varies)		—		68	0
„ Solution		—		5	0
Oxide, per drachm, 20*s.*					
Indigo	0	6	0	0	6
Sulphate	0	6	0	0	6
Iodine, Re-sublimed		—		2	0
Bromide, Sol.		—		2	0
Chloride		—		2	0
Tincture		—		0	8
Iron, Turnings	0	0	6	—	
Filings	0	0	6	—	
Acetate	0	5	0	0	6
Perchloride Solution	0	2	0	0	3
Proto Sulphate	0	1	0	0	2
Sulphide	0	1	6	0	2
Valerianate					
Sulphuret	0	0	6	—	
Lead, pure, in sheets, for Assaying	0	1	6	0	2
Acetate, neutral and terbasic	0	2	6	0	3
„ commercial	0	1	0	0	1
Chloride	0	2	6	0	3
Chromate, fused	0	3	6	0	4
Iodide (varies)		—		3	0
Nitrate	0	4	0	0	4
Brown Oxide	0	5	0	0	6
Proto Oxide, "Litharge"	0	0	6	—	
Red Lead	0	0	6	—	
Lime, pure, from Carara Marble	0	3	6	0	4
Acetate	0	3	6	0	4
Hydrated	0	3	6	0	4
Nitrate	0	3	6	0	4
Water	0	0	3	—	
Litmus	0	3	0	—	
Tincture of		—		0	6
Magnesia, Acetate		—		1	0
Carbonate	0	3	6	0	4
Nitrate	0	6	0	0	6
Sulphate, pure	0	1	6	0	2
Magnesium,					
Chloride	0	4	0	0	6
Hydrated	0	3	6	0	4
Manganese,					
Brown		—		0	6
Peroxide cwt., 12*s.*	0	0	3	—	
Sulphate, Crystals	0	14	0	1	0
Mercury, Distilled (varies)	0	2	6	0	3

	£	s.	d.	s.	d.
		lb.		oz.	
Mercury, Cyanide		—		2	0
Perchloride	0	6	0	0	6
Peroxide	0	14	0	1	0
Subnitrate	0	10	0	0	8
Iodide (varies)		—		3	0
Naphtha, pure, for Potassium		—		1	0
Wood, for burning	0	1	6	0	2
Nickel,					
Crude	0	3	6	—	
Pure	0	12	0	1	0
Sulphate and Potass		—		1	0
Oxalate		—		2	0
Phosphorus	0	5	0	0	6
Platinum,					
Wire		—		32	0
Foil		—		32	0
Chloride		—		28	0
Bichloride, Solution		—		2	0
Potass, Fused	0	4	0	0	4
Solution, sp. grav. 1·270	0	2	0	0	3
Pure, by Water		—		1	0
„ by Alcohol	0	14	0	1	6
Acetate	0	6	0	0	6
Antimoniate		—		1	0
Bicarbonate	0	2	0	0	2
Bichromate	0	1	6	0	3
Binoxalate	0	2	6	0	3
Bisulphate	0	2	6	0	3
Bitartrate, Crystals	0	1	6	0	2
Carbonate	0	1	0	—	
Chlorate	0	2	6	0	3
Chromate	0	4	0	0	4
Nitrate, Crystals	0	2	6	0	3
„ Powdered	0	1	0	—	
Silicate, Crystals					
Silicate, Solution, "basic"	0	2	0	—	
Sulphate	0	2	0	0	2
Bisulphate	0	3	6	0	4
Potassium		—		16	0
Chloride	0	6	0	0	6
Cyanide	0	5	0	0	6
„ pure	0	8	0	0	8
Ferrocyanide	0	2	6	0	3
Ferricyanide	0	6	0	0	6
Iodide	0	24	0	2	0
Sulphocyanide		—		3	0
Sulphide, pure, Crystals		—		1	6
Silica, pure	0	14	0	1	0
„ prepared from fluoride silicon		—		2	0
Flint Powder cwt., 10*s.*	0	0	6	—	
Rock Crystal	0	1	0	—	

	£	s.	d.	s.	d.
		lb.		oz.	
Silver, Foil		—		8	0
Wire		—		8	0
Chloride		—		6	0
Nitrate, Fused		—		4	6
„ Crystals		—		4	0
Sulphate		—		10	0
Oxide		—		8	0
Soda, pure	0	8	0	1	0
„ by Alcohol		—		1	6
Caustic Solution, sp. grav. 1·270	0	2	0	0	3
Acetate, pure	0	10	0	0	8
Biborate	0	1	6	0	2
Bicarbonate, Crystals	0	2	6	0	6
Carbonate, Crystals	0	2	6	0	3
„ Dried	0	5	6	0	6
Phosphate	0	8	0	0	8
Succinate		—		4	6
Soda Lime, for Organic Analysis	0	3	6	0	4
Sulphate		—		0	4
Sulphite	0	2	6	0	3
Sodium		—		10	0
Chloride, Crystals, pure	0	2	0	0	3
Fluoride		—		2	0
Sulphide	0	5	6	0	6
Strontia, Pure, Fused		—		1	6
Strontia, Crystals		—		1	6
Acetate		—		1	0
Carbonate, Native	0	0	6	—	
Sulphate, Pure		—		0	6
Sulphur	0	0	6	—	
Chloride	0	12	0	1	0
Sulphuretted Hydrogen Water	0	2	6	0	3
Tannin, pure		—		1	0
Test Papers, in books, 2*d.* each.					
Tincture of Galls	0	5	0	0	6
„ Turmeric	0	5	0	0	6
Tin	0	2	0	0	3
Granulated	0	2	0	0	3
Tin, Foil	0	2	3	—	
Protochloride Solution	0	3	0	0	3
„ Crystals, pure	0	3	6	0	6
Uranium, Nitrate		—		1	6
Oxide		—		2	0
Urea, pure	0	1	4	—	
Zinc,					
Commercial	0	0	4	—	
Pure, free from Arsenic	0	1	0	—	
Granulated	0	0	6	—	
Chloride, Fused, pure	0	5	0	0	6
Sulphate, pure		—		0	4
Valerianate		—		24	0

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